Bell Laboratories Record

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A Welcome to New Members of the Laboratories

By H. P. CHARLESWORTH
Vice-President

TO meet the steadily increasing demands of its technical problems and its enlarging responsibilities Bell Telephone Laboratories must add correspondingly to its personnel, as well as expand its buildings and equipment. Losses by transfer to other companies of the Bell System, by death, and by severence of employment must also be offset by adding new employees. Such additions, although made continuously throughout each year, are most frequent during the early summer at the conclusion of the school year. This present summer about 500 young men and women will join our Laboratory forces.

It is my privilege, on behalf of the Laboratories, to address a word of welcome to those of you who are now joining your efforts to ours, and will contribute your energies and zeal to our common cause, Bell System service. It is indeed a pleasure to welcome you to this organization, knowing the far-reaching importance of the work which the Laboratories is carrying on in the field of communication, and the excellent opportunities which it offers to each individual for progress and satisfaction. That these opportunities shall continue and that your work shall be efficiently coordinated in our group efforts, is our responsibility, but what you make of these opportunities will depend largely, of course, on your own abilities and your effective team work with those about you.

Our work is indicated by our name, Bell Telephone Laboratories. We are a unit in the system of Bell companies, headed by the American Telephone and Telegraph Company. As Walter S. Gifford, President of that Company, has said, the prime incentive in the work of the Bell System is furnishing ever better and more comprehensive telephone service, at the least possible cost to the public. We are the Laboratory unit of that system, concerned with all the development, designing, engineering and research

work which can best be carried out in a laboratory.

In accordance with the general program of research initiated by the American Telephone and Telegraph Company we carry on basic laboratory investigations in the electrical arts of communication and in the phases of science fundamental to these arts. From these investigations arise new methods of communication, new materials and new principles. These take form in apparatus and equipment which are designed in our Laboratories. As such new equipment or systems are adopted for Bell System use they are specified to the Western Electric Company for manufacture. That company, the manufacturing unit of the System, also looks to the Laboratories for certain engineering services in connection with the equipment which it manufactures or supplies to the operating companies of the System.

These two companies furnish funds for our Laboratory operations, each paying the cost of the services rendered to it. In addition a portion of the development work in the Laboratories, and a corresponding part of the funds which it receives, is undertaken for a subsidiary of the Western Electric Company, Electrical Research Products, Incorporated. This company handles certain by-products of our work, outgrowths of our telephonic researches, such as the systems for sound pictures, which have application beyond the field of the Bell System's broad objective of communication service. A certain amount of manufacturing, large of itself, but small as compared to the enormous volume of the Western Electric Company, is also carried on by the Laboratories in its Tube Shop. Here are made, under the direction of the Laboratories Research Department, all the vacuum tubes and photoelectric cells for the Bell System and for other Western Electric equipment. Taking the total of all its activities the Laboratories at present has a force of about 5,200 and its present expenditure is at the rate of nineteen million dollars a year.

In some part of this large organization, and concerned with one of its many responsibilities, each of you who join with us, will find work which has an important bearing in our program of ever keeping the Bell System in the forefront of the communication art; a task in which you will find great satisfaction and pride of accomplishment. We who have preceded you, in entering upon this interesting work, take great pleasure in welcoming you to this important branch of the Bell System activities.

New Short-Wave Radio Stations

By W. WILSON
Assistant Director of Research

NEW short-wave stations for transoceanic communication have been opened at Lawrenceville, New Jersey, for transmitting and at Netcong, New Jersey, for receiving.

Four channels will be put into operation. One of these will replace the present experimental channel, through which messages have been transmitted from our Deal Beach station and received at Netcong for the last two years.

Two of the others will be added to the European service during the coming months, and the fourth will establish telephone communication with South America.

The Lawrenceville property is approximately 800 acres in extent and has two buildings. The main building houses the general offices and line terminal equipment in addition to two of the radio transmitters. The second building is similar to the first except that provision is merely made for the radio equipment.

Each transmitter is designed for operation on those frequencies in the short-wave range which are found to be necessary for communication during the hours of operation. These frequencies are approximately 19,000, 14,000, and 9,000 kilocycles, corresponding to 16, 22, and 33 meters wavelength.

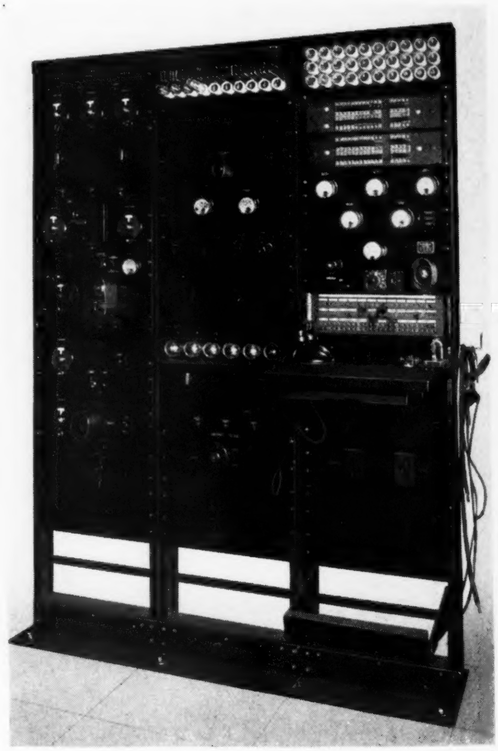
Antenna towers and main building at Lawrenceville

Buildings at Netcong

Carrier power at these frequencies is obtained by amplification of the suitable harmonics from crystal oscillators with fundamental frequencies in the neighborhood of 3,000 kilocycles. Considerable care is taken with regard to constancy of temperature and other operating conditions to ensure the stability of these oscillators.

By the usual method of plate modulation, the voice signals are applied to the carrier, and the modulated power is in turn amplified by two stages employing water-cooled tubes. The output from the sets is fed by transmission lines to appropriate antennas, located in some cases several hundred feet away.

Power for the transmitter is purchased from central-station lines. After transformation to appropriate voltages, that required for plate circuits is rectified and filtered. For the two final stages power is delivered at 10,000 volts from a rectifier employing six water-cooled tubes. Elaborate precautions are taken to insure safety in operation by an interlocking system which prevents the opening of any enclosure before the power has been shut off. In addition the doors of the apparatus are equipped with



One of the short-wave receivers at Netcong. The monitoring operator's position is at the right-hand panel

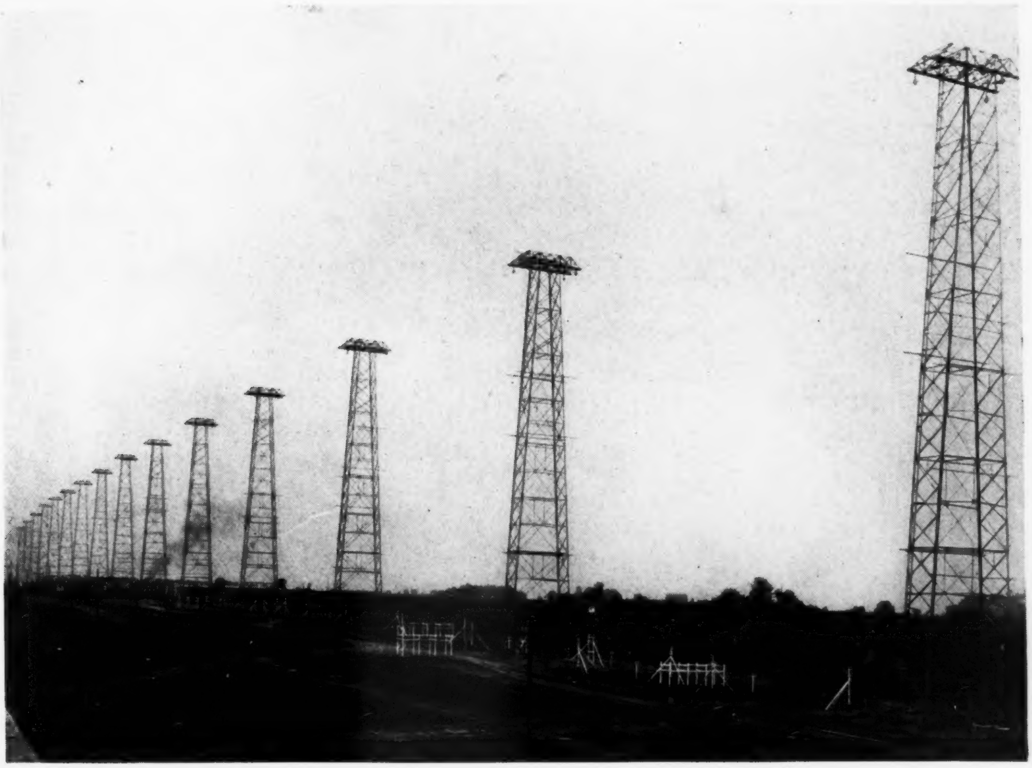
safety switches which throw the main circuit breaker when the doors are opened if there should be any failure of the interlocking system.

One of the advantages of a short-wave system is its adaptability to the use of antennas which concentrate the transmitted energy into a beam in the direction required. This greatly enhances the signal at the receiver.

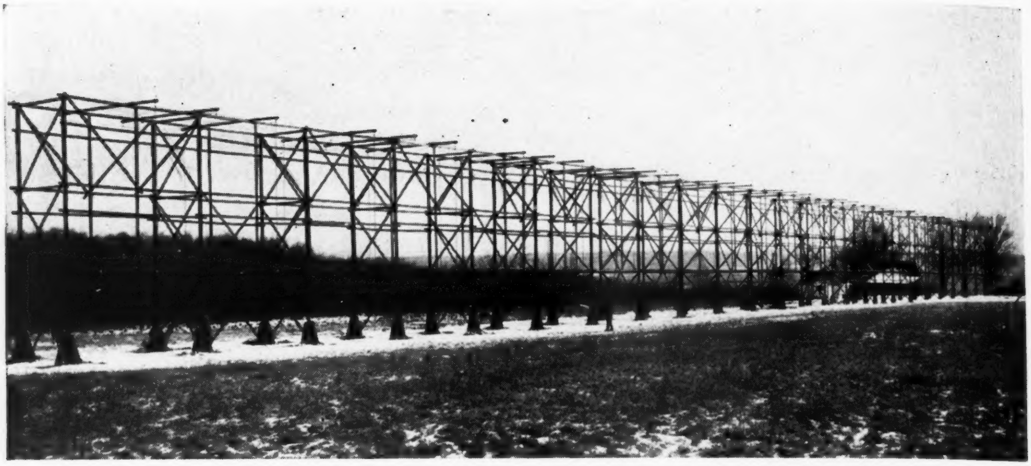
In general, directive antennas are suitable for only one wavelength. Since each transmitter must be able to work on any of three wavelengths, nine antennas are required. These consist of curtains of vertical and horizontal wires strung between towers 180 feet high and 250 feet apart. Each antenna is 500 feet wide and the nine antennas are lined up end to end giving a total length of 4500 feet. The gain to be expected from the use of these antennas over a single vertical wire is from fifteen to twenty decibels.

The Netcong receiving station comprises about 400 acres. As in the case of the transmitting station three wavelengths are needed for each of four receiving sets, necessitating the use of 12 antennas. Each receiving set is housed in a separate building and the general offices and power plant are in still another building.

The receiving sets have two stages of radio-frequency amplification, six stages of intermediate amplification and one stage of audio amplification. An automatic volume control minimizes fading effects. Actual volume at which the energy is put on the telephone line is adjusted by means of re-



A general view of the antenna system at Lawrenceville

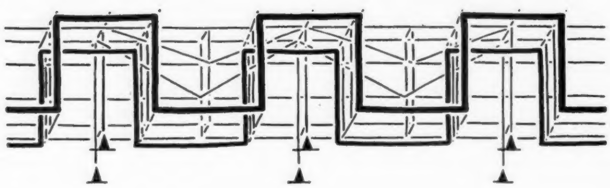


Receiving antenna at Netcong and its supporting structure

peaters in the line terminal equipment.

The antennas used at the receiving end are also directive. Their directivity not only makes them more efficient from the standpoint of picking up signals from a preferred direction but it also by its discrimination against signals coming from other directions materially reduces interference both from static and from other stations. The antennas are six wavelengths long and are connected to their respective sets by transmission lines.

In selecting a site for the receiving station great care was taken to avoid the proximity of well-travelled automobile and airplane routes, because of the interference with signals created by unshielded ignition systems. With the adoption of radio communication for airplanes their ignition systems must perforce be shielded but no relief can be expected from interference from the present type of automobile engine. Limits have been prescribed beyond which automobiles are not permitted unless their ignition systems are adequately shielded. Horses are used for much of the transportation immediately around the station.

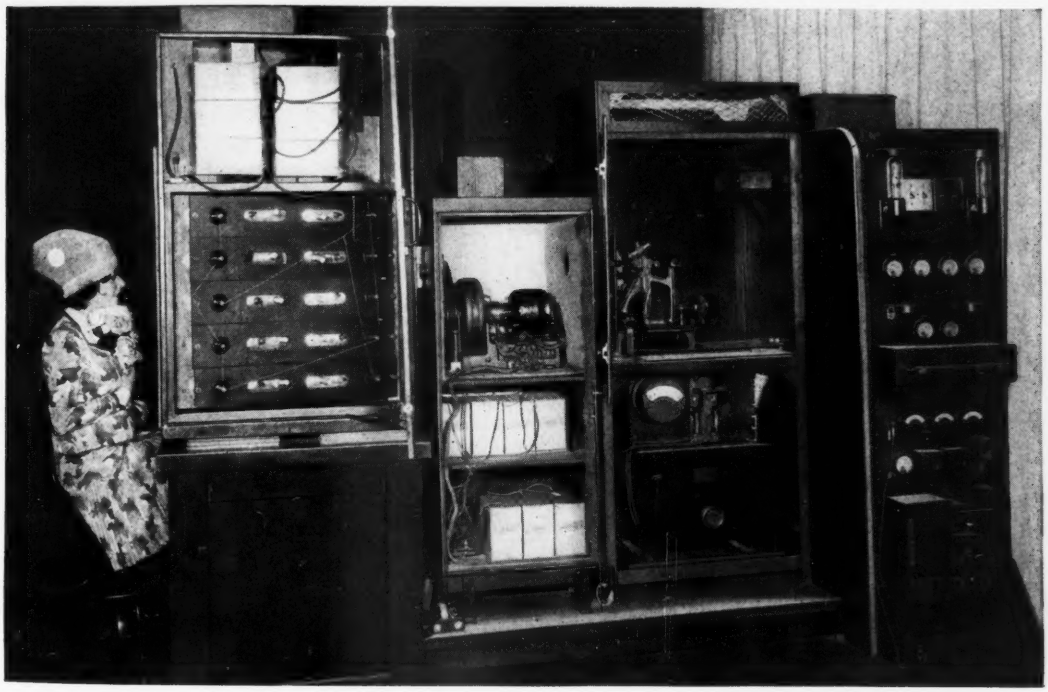


Television in Colors

By HERBERT E. IVES
Research Department

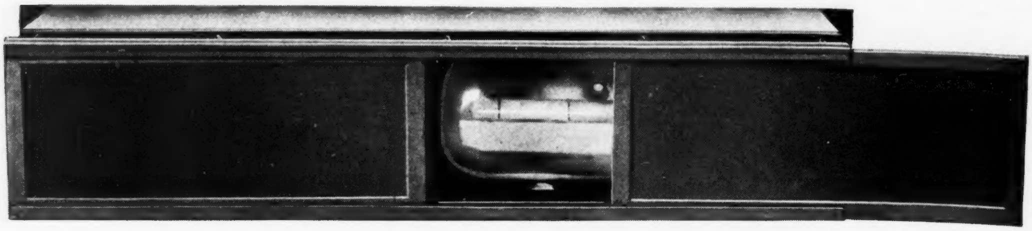
OVER two years ago Bell Telephone Laboratories demonstrated a practical system of television. For the first time successful representations of objects at rest or in motion were transmitted electrically — over wires or through the ether — for considerable distances. The reproduction of the scene then transmitted was in monochrome — the orange-red color of the neon lamp. Recent developments of the Laboratories, however, have made it possible to reproduce scenes with their true color values. The appearance of reality in the reproduced scene is thus greatly enhanced.

One of the most significant features of this new achievement is that it does not require completely new apparatus. The same light sources, driving motors, scanning discs, synchronizing systems, and the same type of circuit and method of amplification are used as in the monochromatic system. The only new features are the type and arrangements of the photo-electric cells at the sending end, and the type and arrangements of the neon and argon lamps at the receiving end. The out-



Side view of sending apparatus with doors of cabinets opened. With the exception of the photoelectric cabinet at the left, the apparatus is identical with that used for the original demonstration of monochromatic television

standing contributions that have made the present achievement possible are a new photo-electric cell, new gas cells for reproducing the image, and the ing landscapes in order to make the blue sky appear properly dark — this defect is corrected and the images assume their correct values of light and



One of the colored gelatin filters partly pulled back to reveal the color-sensitive photoelectric cell in the double container

equipment which is associated directly with them.

To render the correct tone of colored objects, it was necessary to obtain photo-electric cells which — like the modern orthochromatic or panchromatic plate — would be sensitive throughout the visible spectrum. This requirement has been satisfactorily met. Through the work of A. R. Olpin and G. R. Stilwell a new kind of photoelectric cell has been developed, which uses sodium in place of potassium. Its active surface is sensitized by a complicated process using sulphur vapor and oxygen instead of by a glow discharge of hydrogen as with the former type of cell.

The response of the new cell to color, instead of stopping in the blue-green region, continues all the way to the deep red. Because the former potassium cells were responsive only to the blue end of the spectrum, objects of a yellowish color appeared darker than they should have and the tone of the reproduced scene was not quite correct. This disadvantage applied particularly to persons of dark or tanned complexion. When the new cells are used in the original television apparatus and with yellow filters — similar to those used in photographing landscapes in order to make the blue sky appear properly dark — this defect is corrected and the images assume their correct values of light and shade no matter what the color of the object or the complexion of the sitter. It is the availability of the new photo-electric cells which makes color television possible by their use.

The development of color television has been greatly simplified by the fact that as far as the eye is concerned any color may be represented by the proper mixture of just three fundamental colors — red, green, and blue. This fact was utilized in the development of color photography, and all the research that had been done in that field was available as background for color television. A host of methods of combining the three basic colors to form the reproduced image was available but, insofar as the sending or scanning end is concerned, a method was developed which has no counterpart in color photography. The method of "beam scanning" — used in the first television demonstration* — has been employed.

To apply this method to color television, three sets of photo-electric cells are employed in place of the one set used before. Each of these sets is provided with color filters made up of sheets of colored gelatine. One set

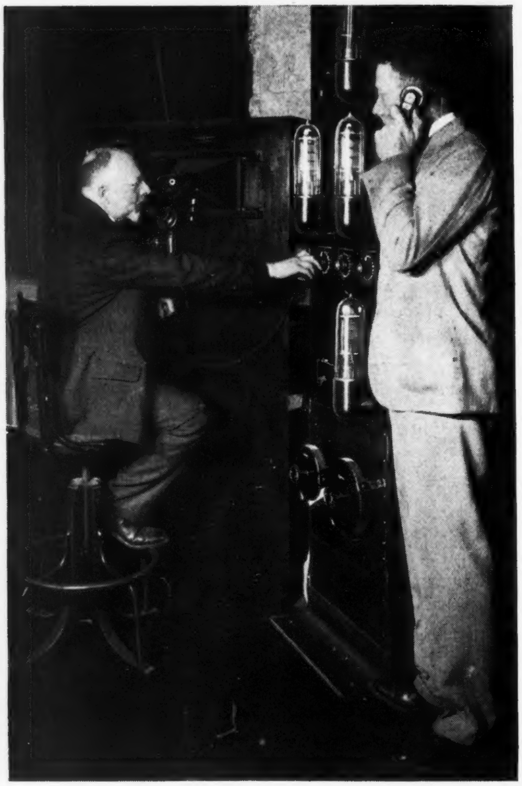
* *See the* Record, *June,* 1928, *page* 325.

has filters of an orange-red color which make the cells see things as the hypothetical red sensitive nerves of the retina see them; another set has yellow-green filters to give the green signal, and the third set has greenish-blue filters which perform a corresponding function for the blue constituent of vision. The scanning disc and the light source are the same as with the beam scanning arrangement used in monochromatic television. The only difference is in the photo-electric cells, and thanks to the tri-chromatic nature of color vision, it is only necessary to have three times the number of cells used previously to reproduce all colors. Three series of television signals, one for each set of cells, are generated instead of one and three channels are used for the transmission of the television signals.

The photo-electric cell container, or "cage," has been built in a somewhat different form from that used in our first demonstration. There three cells were used arranged in an inverted "U" in a plane in front of the object. In the new photo-cell cage twenty-four cells are employed, two with "blue" filters, eight with "green" filters, and fourteen with "red" filters. These numbers are so chosen with respect to the relative sensitiveness of the cells to different colors that the photo-electric signals are of about equal value for the three colors. The cells are placed in three banks, one bank in front of and above the position of the scanned object, one bank diagonally to the right, and another bank diagonally to the left, so that the cells receive light from both sides of the object and above. In placing the cells they are so distributed by color as to give no predominance in any direction to any color. In addition large sheets of rough pressed glass are set up some distance in front of the cell containers so that the light reflected from the object to the cells is well diffused.

The television signals produced in the color sensitive photo-electric cells through the color filters are no different electrically from those used in monochromatic television. Three sets of amplifiers are required, one for each color, and three communication channels in place of one, but the com-

During transmission one sits in front of the apparatus and sees the large sheets of diffusing glass behind which are the color-sensitive photoelectric cells



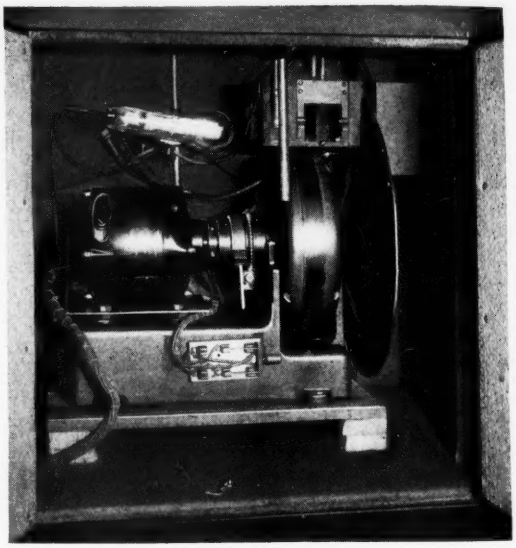
Herbert E. Ives and A. L. Johnsrud adjusting the receiving apparatus of the color television apparatus

munication channels are exactly similar to those which were used with the same scanning disc before.

For color television the three images must be received in their appropriate colors, and viewed simultaneously and in superposition. The first problem was to find light sources which, like the neon lamp previously used, would respond with the requisite fidelity to the high-frequency signals of television, and at the same time give red, green, and blue light. With such lamps available a decision would have to be made as to how the three colors could best be combined to form a single image.

Several methods of reception are possible. For displaying the transmitted image to a large audience a grid* could be employed similar to that used for the earlier demonstration but it would consist of three parallel tubes instead of a single one.

Thus far the television images have been received in a manner similar essentially to our method for monochromatic television. The surface of a disc similar to that used at the sending end is viewed, and the light from the receiving lamp is focussed on the pupil of the observer's eye by suitable lenses. To combine the light of the three lamps, they are placed at some distance behind the scanning disc and two semi-transparent mirrors are set up at right angles to each other but each at 45° to the line of sight.



The disc and motor drive for the color television apparatus are the same as for monochromatic television. The mirror and colored filters are in the small box behind the disc. One of the water-cooled argon lamps appears above the motor

One lamp is then viewed directly through both mirrors and one lamp is

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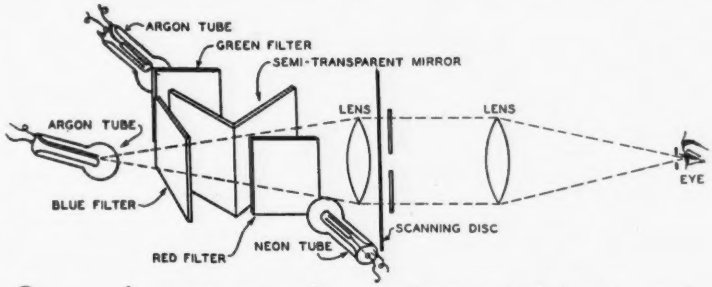
* *See the* RECORD, *May*, 1927, *page* 329.

seen by reflection from each, as illustrated by the accompanying diagram.

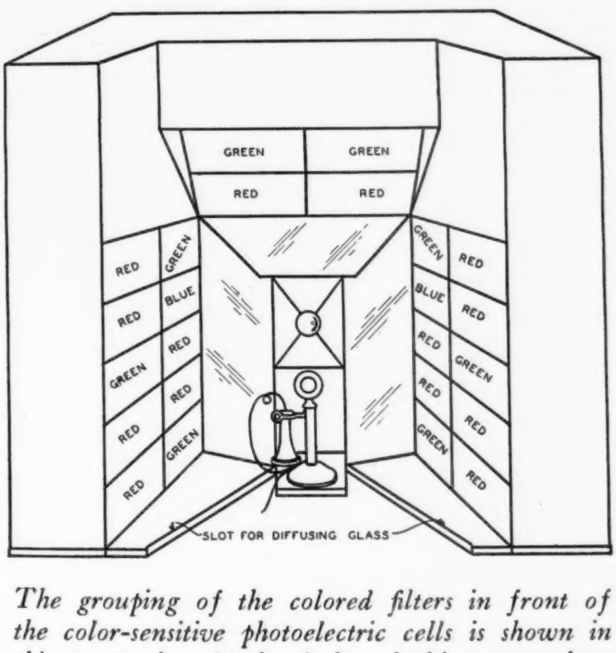
The matter of suitable lamps to provide the red, green, and blue light has required a great deal of study. There is no difficulty about the red light because the neon glow lamp which has been used previously in television can be transformed into a suitable red light by interposing a red filter. For the sources of green and blue light nothing nearly so efficient as the neon lamp was available. The decision finally made was to use another one of the noble gases—argon—which has a very considerable number of emission lines in the blue and green region of the spectrum. Two argon lamps are employed, one with a blue filter to transmit the blue lines and one with a green filter transparent to the green lines of its spectrum.

These argon lamps unfortunately are not nearly so bright as neon lamps and it was, therefore, necessary to use various expedients to increase their effective brilliancy. Special lamps to work at high current densities were constructed with long narrow and hollow cathodes so that streams of cold water could cool them. The cathode is viewed end-on. This greatly foreshortens the thin glowing layer of gas and thus increases its apparent brightness. Even so it is necessary to operate these lamps from a special "I" tube amplifier to obtain currents as high as 200 milliamperes.



One semi-transparent mirror reflects red light from the neon tube; one reflects green light from one argon tube; and through both mirrors passes blue light from the other argon tube

The receiving apparatus at present consists of one of the 16 inch television discs used in our earlier experimental work. Behind it are the three special lamps and a lens system which focusses the light into a small aperture in front of the disc. The observer looking into this aperture receives through each hole of the disc as it passes by, light from the three lamps—each controlled by its appropriate signal from the sending end. When the intensities of

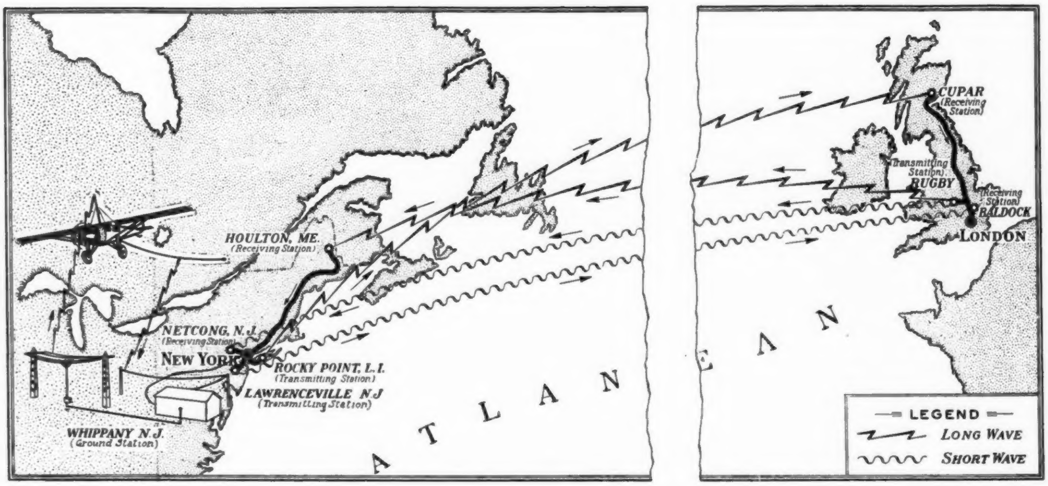


The grouping of the colored filters in front of the color-sensitive photoelectric cells is shown in this perspective sketch of the television transmitter

the three images are properly adjusted he therefore sees an image in its true colors, and with the general appearance of a small colored motion picture.

Satisfactory television in colors is a far more difficult task than is monochromatic television. Errors of quality which would pass unnoticed in an image of only one color may be fatal to true color reproduction where three such images are superimposed and viewed simultaneously. In three-color television any deviations from correct tone rendering throw out the balance of the colors so that while the three images might be adjusted to give certain colors properly, others would suffer from excess or deficiency of certain of the constituents. A further source of erroneous color exists at the scanning end. If the light from the object were not distributed equally to all the cells, the object would appear as if illuminated by lights of different colors shining on it from different directions.

Color television constitutes a definite further step in the solution of the many problems presented in the electrical communication of images. It is, however, obviously more expensive as well as more difficult than the earlier monochromatic form, involving extra communication channels as well as additional apparatus.



AIRPLANE TALKS TO LONDON

Demonstrating further the possibility of telephone conversations by wire and radio, a group of press association men flying in the Laboratories' airplane talked with their correspondents in London, on June 25. Flights were made from Hadley Field with A. R. Brooks as pilot and F. S. Bernhard as radioman. At Whippany, where the channel was transferred to and from wire lines, were F. M. Ryan, L. G. Young, and others of the radio development group. After passing to New York, the conversation was handled over the regular transatlantic circuits

Rotating the "Wax" for Sound Pictures

By L. A. ELMER
Apparatus Development Department

THE machine used in recording sounds on phonograph discs synchronously with associated pictures consists essentially of a turntable, bearing the "wax" and rotated by a synchronous motor* of constant speed, and an electrically driven stylus** cutting the record. In the design of this machine the primary aim is to ensure that the record is both faithful to the original sounds and synchronous with the pictures. Fidelity in the performance of the stylus would be vitiated by departures from uniformity in the speed of the turntable while sounds were being recorded or reproduced. Although a constant speed motor is used, its value would be destroyed if the machinery transmitting the drive from motor to turntable were not equally free of velocity variations. Thus the problem of fidelity involves not only the motor and the stylus but all the moving parts of the machine.***

Even were it possible to connect the motor directly to the turntable, casual variations in the speed would arise, from varying frictional loads on the turntable and bearings. But direct connection is unsatisfactory. Because the turntable must operate at a lower speed than the motor (one thirty-sixth of that speed), reducing gears must intervene. In the actual apparatus the motor drives (through a horizontal coupling) a worm engaging a worm wheel which drives (through a vertical coupling) the shaft to which the turntable is attached.

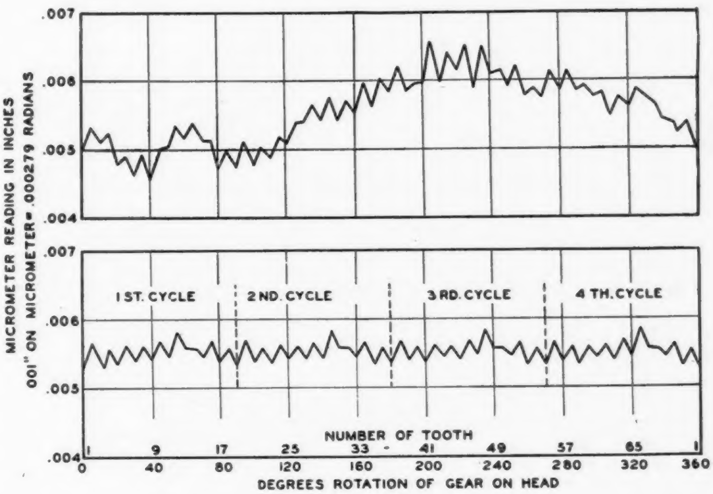


Fig. 1—Above: difference between actual and correct positions of teeth on a typical gear, relative to an arbitrary reference position. Below: averaging effect of dividing same gear into four layers, calculated from data (above) for one layer

It is cyclic speed-change that must be guarded against in this mechan-

* *H. M. Stoller,* RECORD, *November, 1928.*
** *H. A. Frederick,* RECORD, *November, 1928.*
*** *To be described in the Journal of the American Society of Mechanical Engineers this autumn.*

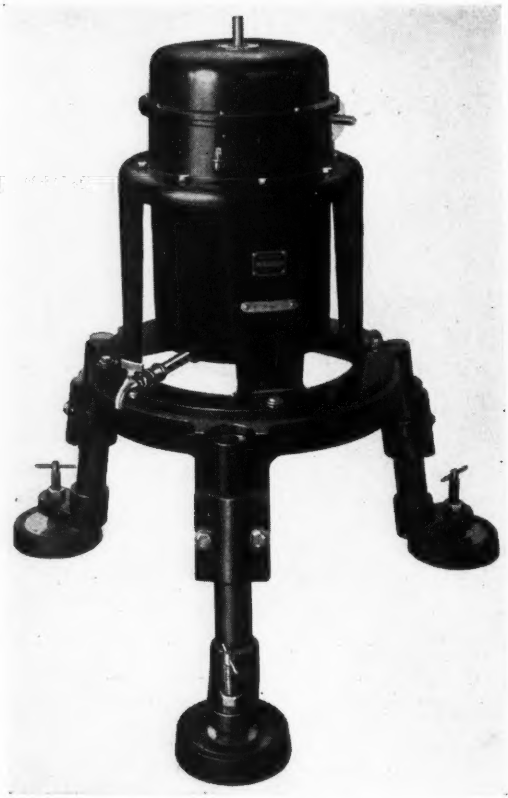


Fig. 2—The mechanical filter for turntable drive, as it appears in a commercial disc-recording installation

ism; all such changes with frequencies from about one-half cycle per second up to the higher limit of audibility are to be avoided. Speed changes at audible frequencies introduce extraneous sounds into the records, and speed changes at frequencies below the audible range produce changes in pitch. There are in general two points of origin for these variations: the turntable and its bearings, and the gears. Speed-changing variations in load on turntable and bearings are most likely to have the frequency of the rotation of the turntable (a little more than one-half cycle per second). From the gears three sorts of variation arise, —those accountable to inaccuracies in the spacing of the teeth (Figure 1), to errors in the shape of the teeth, and to the successive shifts of driving load from tooth to tooth. Together these may occasion variations with quite a range of frequencies.

The extent to which these variations are permissible is determined, for low-frequency changes, by the smallest change in pitch the ear will notice when pitch-variation is continuous. It appears that, when a pure tone is projected by a loud speaker of high quality, the ear can detect variations in its pitch which exceed one-tenth per cent of its frequency. This sets a severe requirement for constancy of rotation.

It is, furthermore, an overall requirement, for it applies to differences between the original and reproduced sound; and both a recording and a reproducing machine intervene between these sounds. Since both operate at the same speed, and since there is a high probability that the ultimate record will be lined up on the reproducer correspondingly to the "wax" on the recorder, variations in the speeds of the two are likely to be additive in their effects upon sound pitch. The sum of the variations permitted in the two, therefore, must not be greater than the total permissible variation for the system as a

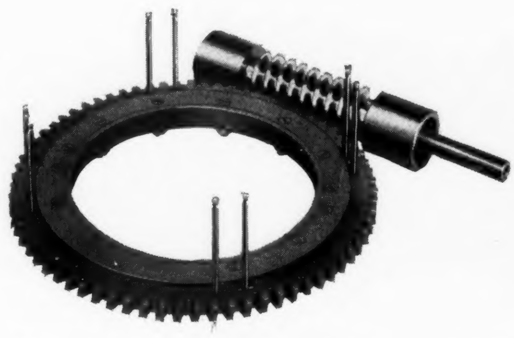


Fig. 3—The reduction gearing: a worm and a four-layer worm-wheel

whole. Since the more its velocity characteristics are made constant the more the apparatus costs, it is economical to be stringent in requirements for constancy in the recorder, of which comparatively few are manufactured, and more lenient in those requirements in the more numerous reproducers. An economical division between the two machines of the total allowable error appears to be in the ratio of one to four. The demand for constancy thus placed upon the recorder is far higher than can be met by gears and bearings of even the most careful construction. It is a demand which can be filled only by special means.

The fact that a continuous, slightly varying, motion of this sort is mechanically analogous to a slightly varying electric current helps to explain what these means are. A pulsating current can be treated as a direct current on which small alternating currents are superposed. The suppression of the alternating currents, to leave the unvarying direct current desired, can be accomplished by an electric-wave filter which attenuates the undesired alternating components. The electric filter consists of suitably interconnected coils, condensers, and resistances. Since mechanical analogs of these circuit elements are respectively to be found in masses, springs, and dissipative plastics, the mechanical-vibration filter can be visualized in terms of electrical principles.

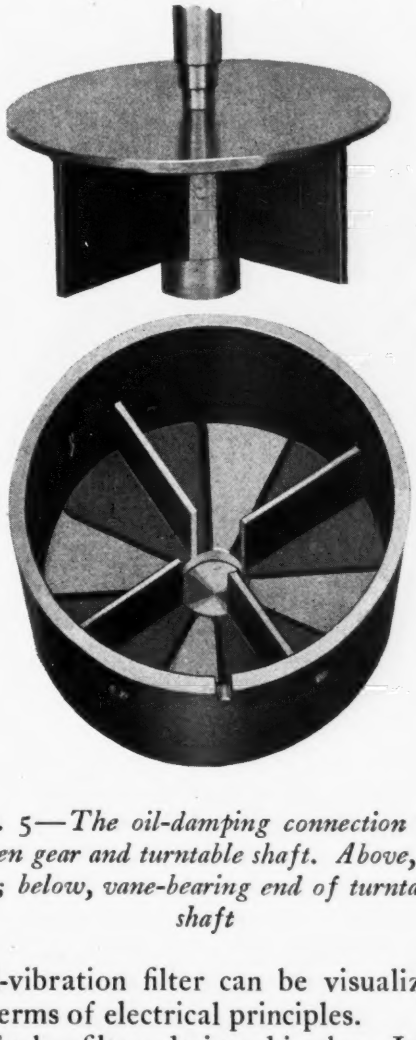


Fig. 5—The oil-damping connection between gear and turntable shaft. Above, oil cup; below, vane-bearing end of turntable shaft

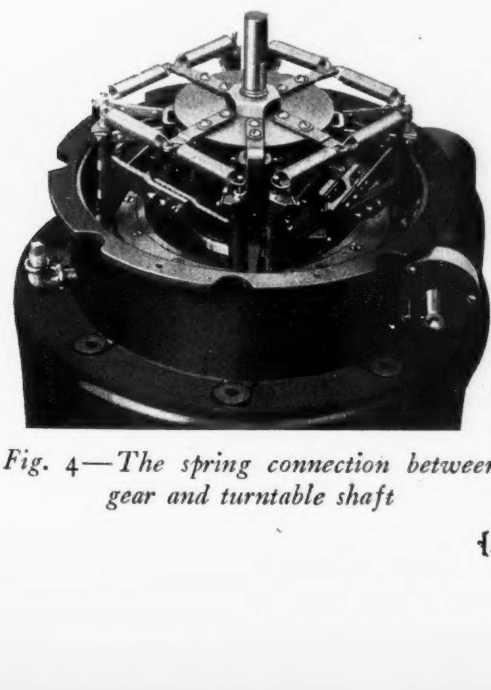


Fig. 4—The spring connection between gear and turntable shaft

Such a filter, designed in these Laboratories, is incorporated (Figure 2) in the Western Electric Company's commercial disc-recording apparatus. It uses coil-springs as its capacitances, viscous oil for its resistances, and the masses of its moving parts as its inductances. The great width of the frequency band to be attenuated, and the plurality of the sources of the varying-force, considerably complicate

the problem of determining what values of stiffness, weight, and dissipating ability should be used. For example, variations due to gear in-

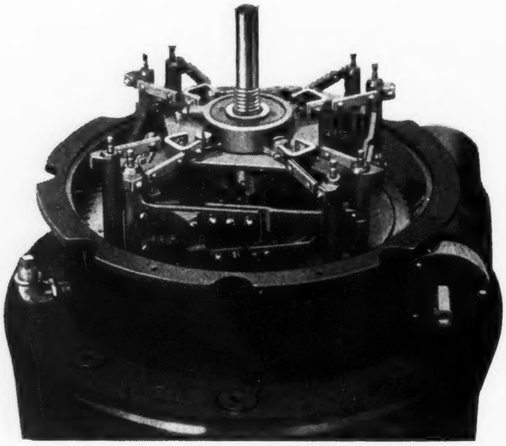


Fig. 6—Linkage mechanism and its braces, through which the gear drives the oil cup

accuracies are most readily absorbed by very flexible springs, whereas disturbances due to varying loads are best prevented from affecting turntable speed by the use of stiff springs. The filter finally designed embodies a compromise between these conflicting demands. Its general construction is such that the worm-driven gear drives the turntable shaft through the linearly flexible springs, and relative motion of the gear and shaft is damped by the oil.

The gear (Figure 3) is made in four layers. These layers are clamped together when the teeth are cut, and each layer is afterwards rotated ninety degrees relative to the adjacent layer. All are finally mounted, in engagement with the worn wheel, so that each can move independently of its companions. To each layer two cross-braced posts are rigidly attached, from the tops of which (Figure 4) springs lead to lugs on a plate fastened to the turntable shaft. Thus each layer of the gear independently drives the shaft through two springs. It is apparent that the offset four-layer structure of the gear divides by four the amplitudes of the disturbances caused by inaccuracies in the teeth, since at any one time, each affects but one of the four sets of springs. This structure also multiplies by four the frequencies with which these disturbances occur, since each inaccuracy in cutting is made to occur once for every 90 degrees, instead of once for every 360 degrees, of rotation. This higher frequency is far more readily absorbed by the filter than the lower would be.

The oil connection between gear and turntable shaft is effected by permitting the layer-gear to rotate a vane-bearing oil-filled cup, into which dip vanes attached to the turntable shaft (Figure 5). The mechanism

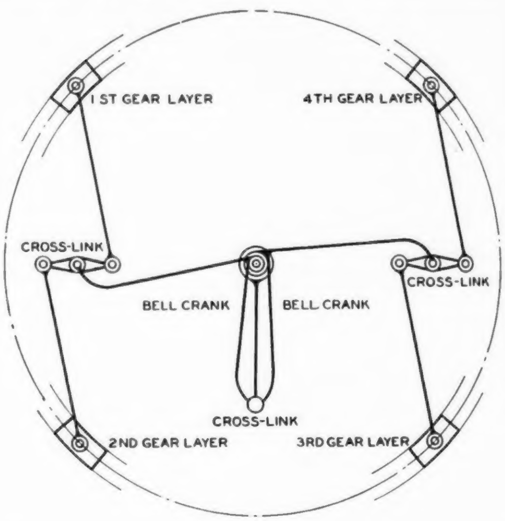


Fig. 7—Schematic diagram of linkage. The bell-cranks are pivoted at the center of the mechanism but are not attached to the shaft. The third cross-link, between the ends of the bell-cranks, is perpendicular to the plane of the diagram. From its center extends the only member which has a rigid connection at the center of the mechanism, to the collar which drives the oil cup

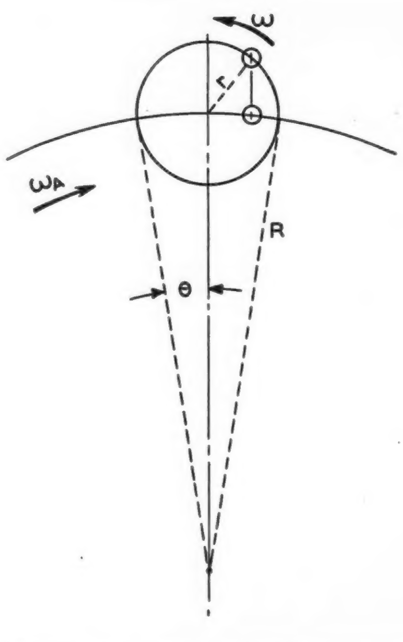
(Figure 6) through which the gear drives the cup is in this case rigid rather than elastic, but is again one whereby the effect of a gear irregularity upon the cup is quartered in amplitude and quadrupled in frequency. This mechanism is a system of links independently driven by each of the layers of the gear so as jointly to rotate the cup with their average velocity. To each layer, again through the perpendicular posts, is attached a link (Figure 7). The members of one and the other pair of these links are flexibly joined by cross-links, to the center of each of which is pivoted one end of a bell crank. The other ends of these two bell-cranks are in turn flexibly joined by a third cross-link, to whose center the member which drives the cup is attached. It is apparent that the motion of the center of each cross-link is the average of the motions of its two ends. Each of the first two cross-links, therefore, averages the motions of two of the gear-layers, and the third cross-link averages the motions of the first two cross-links, driving the oil cup with the average motion of all four gear-layers.

Fig. 8—Steps in the development of the linkage, showing its successively more rugged construction

Because the deflections with which this apparatus is expected to operate are very small, it is essential that no motion be lost by "backlash" in pivots. For this reason, and to minimize pivotal friction, flat reed-springs are used for all joints. Since the linkage cannot be constructed in a single horizontal plane but must be built in several planes, it is subject to warping forces which tend to produce velocity errors. To avoid these, the linkage is extensively braced (Figure 8).

In the development of this filter, reliance upon theory had to be supplemented by measurements of the effectiveness of various models. Since smooth rotation of the turntable was in view, fluctuation in turntable speed was the performance to be directly measured. This was accomplished stroboscopically. On the rim of the turntable 216 accurately spaced groves were cut. A disc, with six radial slots, was connected by a rigid drive to the shaft of the synchronous motor. The disc was so placed that the grooves on the rotating turntable could be observed one by one by a microscope looking through the slots in the rotating disc. Observed through this apparatus, the groove on the edge of the rim appears to stand still when the speed of the turntable is exactly one thirty-sixth the speed of the motor. A small error in turntable speed causes the image of the groove to change position momentarily. The amount of this shift can be read in thousandths of an inch on a filar micrometer placed in the eyepiece of the microscope. From this reading the percent velocity variation can be calculated (Figure 9).

The model finally developed drives the turntable with remarkable constancy. Of the velocity variations from the two major sources of error — from varying loads, at one cycle per revolution, and from varying gear-spacing, at four cycles per revolution — the former has been reduced to 0.04 per cent and the latter to a point below the limit of measurement. Supplemented by suitably modeled drives for reproducing machines, recording drives of this type provide ample insurance against maltreatment of sounds by driving machinery.



$$\omega_A = \text{Av. Turntable Vel.}$$

$$\omega_A + \frac{\omega r}{R} = \text{Max. Turntable Vel.}$$

$$\omega_A - \frac{\omega r}{R} = \text{Min. Turntable Vel.}$$

$$\omega = \text{Angular Velocity of Vibration} = 2\pi f.$$

$$2\frac{\omega r}{R} = \text{Velocity Variation}$$

$$200\frac{\omega r}{\omega_A R} = \text{Velocity Var. in per cent.}$$

$$200\frac{\omega r}{\omega_A R} = 200\frac{\omega}{\omega_A}\theta$$

$$\theta = \text{Amplitude in Radians}$$

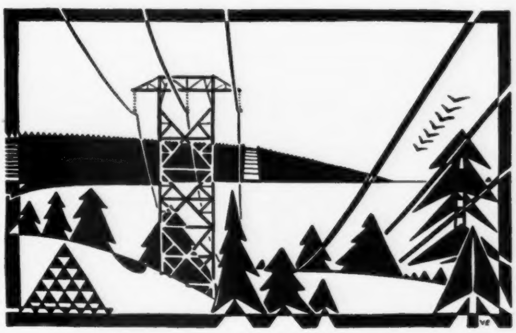
$$\text{When } \frac{\omega}{\omega_A} = 1, \qquad 200\frac{\omega r}{\omega_A R} = 200\,\theta$$

Fig. 9—Method of converting stroboscope micrometer reading to per cent velocity variation. The curve of large radius represents the rim of the turntable, and the curve of small radius represents the familiar diagram of harmonic motion. At the projection of the end of the small circle's radius is a groove on the turntable rim. The quantity read on the micrometer is 2r,—the maximum motion of a groove

A Carrier Telephone System for Power Lines

By C. F. BOECK
Apparatus Development Department

IN the operation of a system for generating and distributing electric power, dependable communication between the power stations is an essential requirement. The necessary communication facilities can usually be obtained to advantage from the local telephone company. In certain cases, however, the power plants are in such inaccessible and unpopulated communities that the telephone company's facilities are not readily available. The power plants may be widely separated, perhaps hundreds of miles from the community to which current is supplied. The costs involved in constructing a separate telephone circuit may be excessive. Under such circumstances, the strongest and probably the most direct physical link connecting the stations with the power system is made up of the power wires themselves. Their size, and the towers on which they are supported make them proof against any conditions but the most severe, and offer a dependable communication path.



Such a situation confronted the Pacific Gas and Electric Company, which supplies much of the electric power for San Francisco and the neighboring communities. Most of this power is generated at hydro-electric stations more than 200 miles away, in the northern part of California, and it is transmitted for about 200 miles of the distance by a 220,000-volt line built on a cleared right-of-way largely over mountains and heavily wooded country. The Electric Company had built a private telephone line on a separate right-of-way, but this was of course subject to damage by heavy storms. It was decided therefore to use the power transmission wires as a communication channel, and equipment for telephone service by carrier current was therefore installed. Facilities were provided for communication between the load dispatcher at Oakland, who directs operation of the system, and the operators at the Claremont and Vaca-Dixon distributing stations and the Pit River No. 1 generating station.

Systems for telephone conversations over power lines by carrier current are not new; the first one installed by Western Electric was for the Georgia Railway and Power Company, in 1924, and others have been constructed and installed since, for power companies throughout the country. Carrier telephone systems have also been made by other electrical manufacturers. Since the Georgia in-

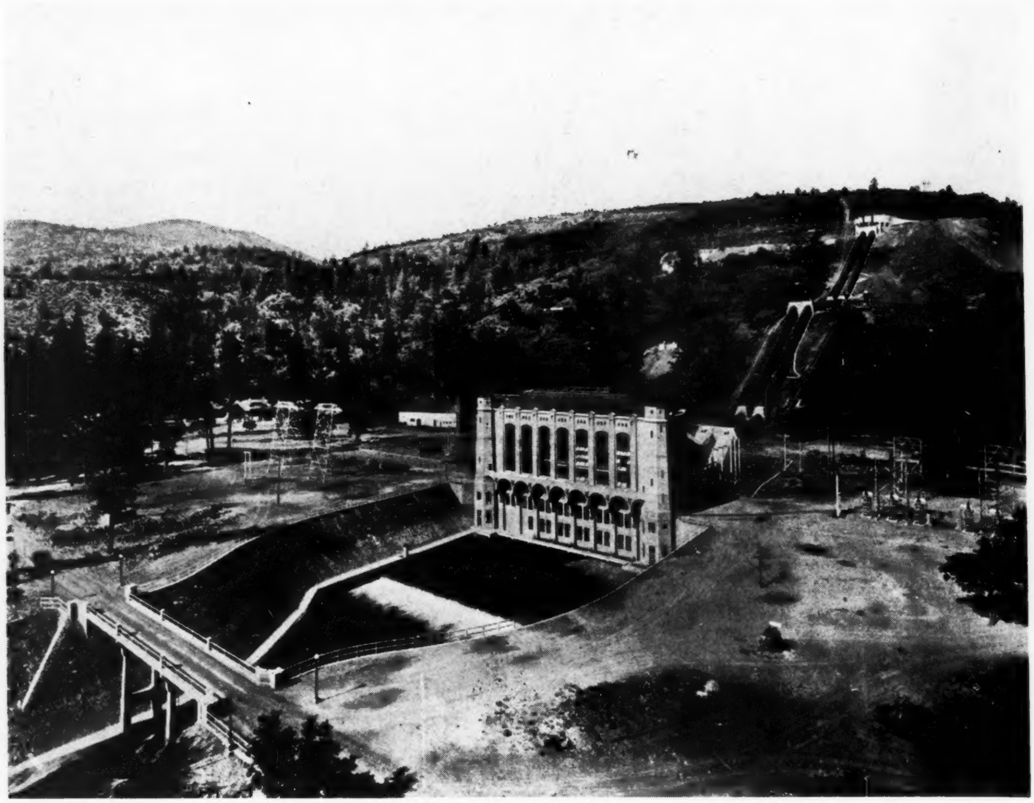


Fig. 1—Pit River Power Station No. 1 of the Pacific Gas and Electric Company

stallation, the Western Electric systems have profited from the course of development taken by carrier systems for use on telephone circuits, and have been redesigned from time to time, as development work opened the way to improvements. Marking the greatest advance to date is the recently designed system which had its first commercial application in the installation for the Pacific Gas and Electric Company.

To this system is given the full descriptive title, "carrier suppressed, single side-band, single frequency, duplex, power line carrier telephone system." The carrier current itself is not transmitted, and only one of the side-bands resulting from modulation by the voice currents is transmitted. Duplex service is offered — that is, speech is transmitted in both directions, with current of the same frequency. In addition, modulation and demodulation take place in two stages, but since that circumstance does not describe the traffic possibilities directly, it is not mentioned in the title.

The general plan of operation is shown in Figure 2, which gives a block schematic of the principal equipment at any one terminal. For connecting with the power line, the same coupling equipment is used jointly for messages in both directions. Likewise, unless separate circuits are installed from the telephone transmitter to the transmitting equipment and from the receiving equipment to the telephone receiver, there must be a

circuit which will segregate outward and inward messages passing over it. Otherwise the received and demodulated currents would pass directly to the transmitting equipment, and would continue in a closed loop through transmitting and receiving equipment. The separating circuit, known as the voice-frequency hybrid circuit, is the point at which the outgoing currents meet the terminal equipment, and the received currents leave it.

Between the hybrid circuit and the coupling circuit outgoing and incoming currents pass over separate paths. From the hybrid circuit, the currents to be transmitted go to the duplex control circuit, which determines the direction in which the terminal equipment operates at any moment. The transmitting circuit is normally inactive and the receiving circuit active. While a user speaks at the transmitter, however, the duplex control circuit reverses this situation, putting the transmitting circuit into active operation and making the receiving circuit inactive.

The modulating and demodulating circuits are separate, and each deals with currents passing in one direction only. Since carrier current of the same frequency is used for transmission in both directions, the oscillators and certain of the auxiliary pieces of apparatus are common to both the transmitting and receiving circuits.

When the system is in use, voice currents from the telephone instrument go first to the hybrid circuit, whence they are impressed jointly on the first modulator and the duplex control circuit. In response, the latter raises the grid bias of the tubes in the receiving equipment sufficiently to stop operation, and after a delay of a few thousandths of a second lowers to normal the grid bias of a pair of tubes in the transmitting equipment. Thus the receiving equipment is shut off and the transmitting equipment made active for the duration of the outgoing voice message, with an intervening delay to prevent momentary access to the receiving equipment by the modulated currents to be transmitted. The first modulator is of the well-known "push-pull" type; there the voice currents are impressed on a carrier wave of 28,600 cycles. At the next element, the modulator band-pass filter, the carrier leak and upper sideband are both suppressed, and the lower sideband is transmitted to the second modulator, which is also of "push-pull" design. The carrier frequency supplied to it can be varied through the range of 70,000 to 170,000 cycles, and the tuned circuits involved can be adjusted correspondingly, so that the sideband to be transmitted can be

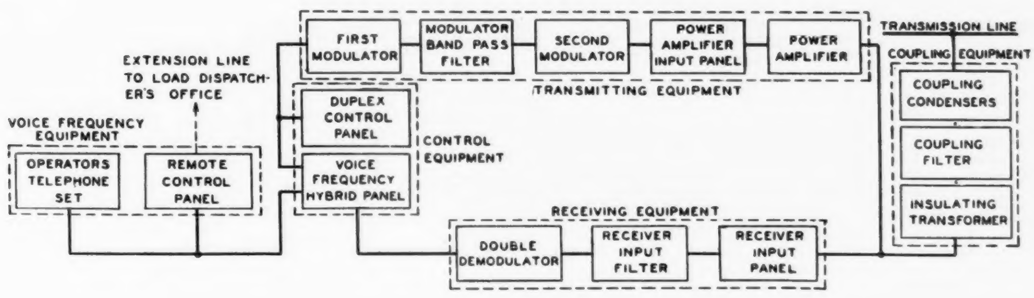


Fig 2—Block schematic of the carrier system

placed anywhere in the range suitable for power-line-carrier transmission—50,000 to 150,000 cycles. In the second modulator there are produced two sidebands which, since the modulating currents form a band between the frequencies of 26,100 cycles to 28,400 cycles, are some 50,000 cycles apart and can be separated by comparatively simple discriminating networks. The separation takes place at a double-tuned transformer joining the second modulator and the power amplifier. In addition to acting as output transformer for the modulator

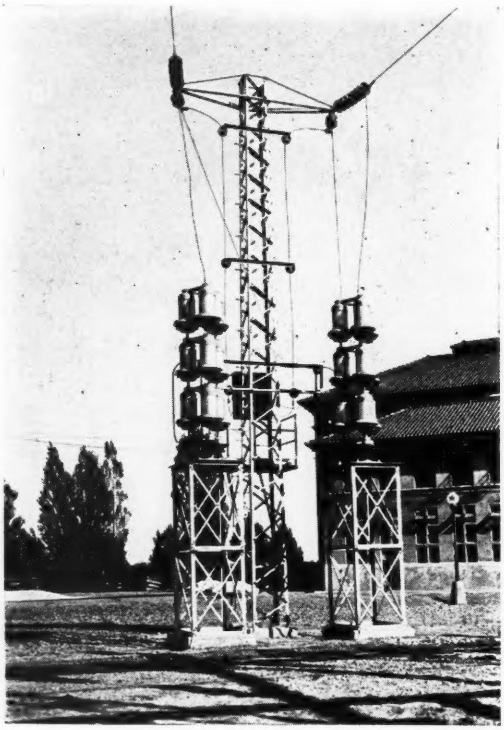


Fig. 3—Coupling condensers for 110,000 *volt lines*

and input transformer for the amplifier, this member is effectively an adjustable band-pass filter readily adjustable to transmit a band 2500 cycles wide anywhere in the range from 50,000 to 150,000 cycles. The adjustment is correlated with that of the oscillator of the second modulator, so that only the lower band is allowed to pass through to the power amplifier. There its power is raised to 100 watts.

At that point the modulation and amplification are over, and the current is ready to be impressed upon the power line, through the coupling equipment. First it passes to the insulating transformer, whose functions are to prevent unbalancing of the circuit and, by virtue of the insulation, to give additional protection to the equipment. This transformer is the point of contact between the terminal equipment, in which one of the wires is grounded, and the leads to the power line, which are balanced electrically around a ground connection at the mid-point of a drainage coil which is part of the coupling filter. Then the current goes to the coupling filter. In addition to acting as a filter to suppress currents outside of the frequency band wanted, this member drains from the leads the 60-cycle current transmitted to them through the condensers; providing a low resistance path to ground for this current, it keeps down the voltage in the leads. The last step taken by the current is to the coupling condensers which are the actual point of contact with the power line.

When the speaker is finished, the duplex control panel blocks the transmitting circuits and simultaneously places the receiving circuits into active operation. Then the response from the distant station, reaching the coupling equipment, passes in order through coupling condensers, coupling filter and insulating transformer, and is made ready for demodulation. First it is impressed upon the receiver input circuit, by which its power level

is adjusted for the subsequent equipment. Then comes the receiver input filter which, like the coupling filter, attenuates accidental currents of other frequencies; it is an adjustable band-pass filter having the same range as the coupling filter. Passing that point, the high-frequency currents are impressed upon the demodulator, where they are translated in two steps to their original voice frequencies. The two carrier frequencies are the same as those used in modulation, and they are supplied by the same oscillators, but the steps take place in reverse order. Hence the intermediate currents, after the first stage of demodulation, are of the same frequency as the outgoing currents between the first and second modulators.

Signalling is accomplished with pulses of 1600-cycle current, supplied to the first modulator of the calling terminal and progressing from there to the transmission line just as would voice currents. At the other terminals of the system, the incoming signals pass through the receiving equipment and are restored to their original 1600-cycle frequency by double demodulation. Thereupon they go to the signal-receiving circuit, not shown in the block schematic. This is a branch from the main receiving circuit, to which go part of the incoming currents after demodulation, as long as the receiver remains on the switchhook. The currents are amplified and rectified, and in the plate circuit of the rectifier operate a relay controlling a train-despatching selector which responds only to a predetermined combination of signal pulses. Thereupon signal current is connected at the station, to indicate that a call is waiting. As soon as the receiver is removed from the switchhook however the signal-receiving circuit is disconnected.

Like most other telephone systems, a system using carrier current on a power line must give duplex service — that is, it must transmit speech in both

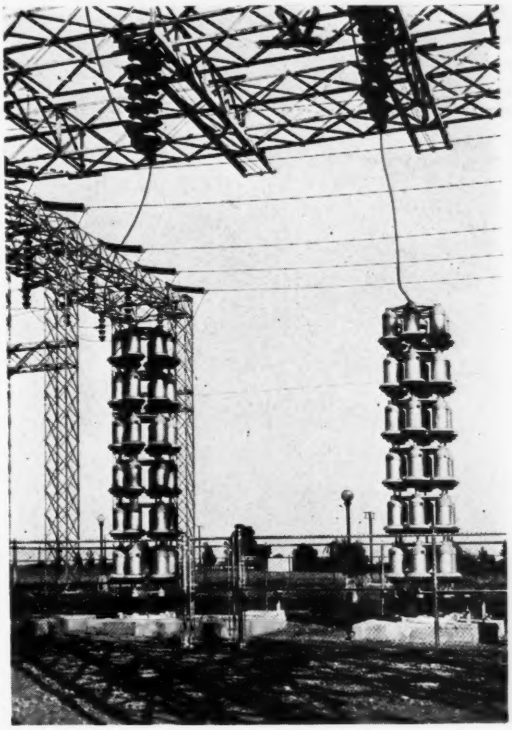


Fig. 4—Coupling condensers for 220,000 volt lines

directions. Carrier telephone systems on communication lines ordinarily use separate frequency ranges for the two directions. This power line carrier system, however, on account of the characteristics of the power lines, was designed to transmit currents in both directions with the same modulating frequency. Most power lines are marked by wide discrepancies in their transmission-characteristic curve, with peaks and valleys only a few kilocycles apart. At the present state of development, it is usually difficult to predict accurately the best frequency range

for conversation over a particular network of power lines. On that account it is necessary to design equipment readily adjustable to the most suitable range at any particular installation. Accordingly a single-frequency system is more flexible, and can be more readily installed on a complex network of power lines, since a single usable frequency range can be located more readily than can two. In certain cases, furthermore, several carrier channels may be wanted on a single transmission line particularly when that line connects two or more power systems. Where each channel uses a single band of frequencies, satisfactory spaces can be found for additional channels which might already be occupied were two bands to be needed for each.

Fig. 5—Terminal equipment—rear view

Although both sidebands produced by modulation and the carrier current itself could be transmitted, it is sufficient to transmit one of the sidebands only and to supply current of the carrier frequency, at the receiving station. With the latter arrangement, a band of frequencies only 2500 cycles wide need be transmitted, whereas for reproduction of the same quality a band of at least 5000 cycles must be transmitted when both sidebands are used. On account of the irregular transmission characteristics of most power lines, it is difficult and sometimes impossible to find a band 5000 cycles wide, over which transmission is uniform. Satisfactory bands of half the width are much more numerous, and the variation in transmission throughout their range is ordinarily considerably less.

Just as a single-frequency system requires half the frequency space of a two-frequency system, a single-sideband system uses about half the space of a two-sideband system. That advantage is of course valuable on power lines where several telephone channels are wanted. Such demand for several channels has however been somewhat limited so far.

In demodulating circuits of the type used in this equipment, loudness of the received speech depends on the amplitude of the carrier and that of the sideband. In this system, therefore, the loudness is less affected by changes of the transmission loss of the line than in any system where the carrier is transmitted. In that case, carrier as well as sideband undergo

variable attenuation whereas here the carrier frequency is produced for demodulation at the receiving end and its amplitude is independent of transmission conditions on the intervening power line.

Likewise the system has a greater effective transmitting range than any carrier-transmitted system which delivers the same high-frequency power to the transmission line. The carrier current, produced at the receiving end, is of course not attenuated by the line, and the sideband current makes up all of the current delivered to the line, rather than only a third of it as in carrier-transmitted systems. Attenuation of the sideband current may therefore be much greater than in a carrier-transmitted system if the received speech in the two is to be of the same loudness.

By adoption of double modulation, the necessary band-pass filters have been greatly simplified. Such filters are used on all the long distance telephone circuits operated with carrier currents, but they would become extremely complicated if their frequency range were to be raised to any value likely to be used for a power-line system. Were it desired to separate the upper and lower sidebands of a 30,000 cycle current modulated by currents from 0 to 2000 cycles, it would be quite feasible to build filters passing respectively the bands from 28,000 to 30,000 cycles, and from 30,000 to 32,000 cycles. Were the carrier frequency 100,000 cycles however, it would be both difficult and expensive to build either fixed or adjustable filters to distinguish between the bands of 98,000 to 100,000 cycles, and 100,000 to 102,000 cycles. With upper and lower sidebands from the second modulator more than 50,000 cycles apart, the function of separation is comparatively simple and networks are used which are readily adjustable should any changes be wanted in the carrier frequency.

The equipment is mounted on standard relay racks, with the various circuit elements built upon individual panels. In conformity with power-plant practice, all tubes and other apparatus are mounted on the rear of the panels, with only the control and meters appearing on the front.

There are four bays at each terminal in all, shown in Figure 6. On the left is the receiving bay, with the receiving equipment and the rectifier which supplies plate voltage for the

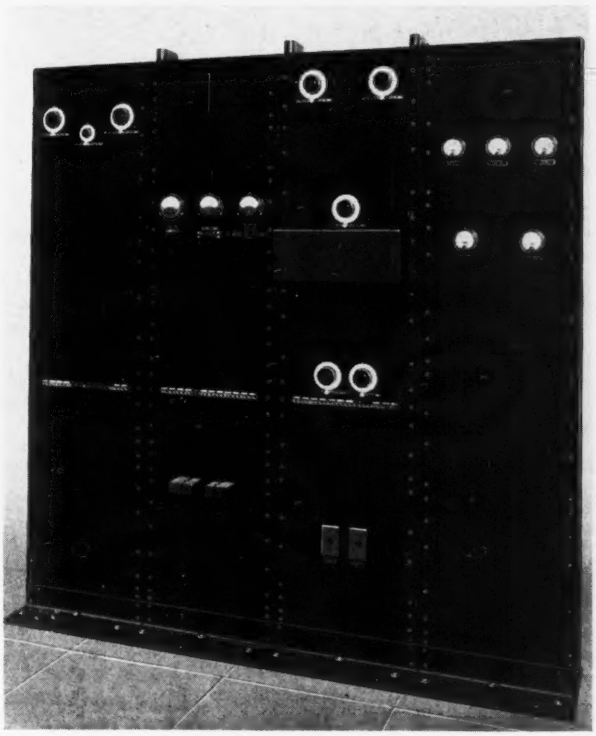


Fig. 6—Terminal equipment—front view

low-power vacuum tubes. Next is the signalling bay, on which are mounted the signalling circuit, the duplex control circuits, and extension equipment which makes it possible to control the terminal from a remote station. On the third bay, the transmitter bay, are mounted the two modulators, the band-pass filter which connects them, and a control panel for power supply. The bay on the right is called the power amplifier bay, and on it are mounted the power amplifier and the associated circuits for current supply.

Ship-to-Shore Telephone Service

The project of extending telephone service to ships at sea, upon which experiments were conducted some years ago, is being actively taken up anew, with the expectation of offering to the public commercial ship-to-shore telephone service. Arrangements are being made to construct shore receiving and transmitting stations in New Jersey, suitable for handling a general service along the transatlantic steamship lanes and for the installation of a laboratory model transmitter and receiver aboard the S.S. "Leviathan." Pending the completion of the commercial shore transmitting station, and during the initial engineering tests, transmission will be carried out from the Deal Beach experimental station.

Eight radio channels have been assigned by the Federal Radio Commission for experimental work; their carrier-frequencies range from 1608 kilocycles to 17,300 kilocycles. Since the course of transatlantic vessels is along fairly well-defined routes, directive antennas will be used. It is planned to install in the shore station the same equipment as is used at the Lawrenceville and Netcong transatlantic stations.

Capability Engineering of Step-by-Step Relays

By F. H. HIBBARD
Apparatus Development Department

WHAT a piece of apparatus or equipment is capable of doing is often easy to determine. It may have been designed for only one thing and perhaps is capable of nothing else. There are, however, pieces of equipment that, with slight rearrangement of their parts, can perform many different operations. Here a prediction of capability is not so easy and capability engineering may be defined as the preparation of such complete data regarding the characteristics of an apparatus as to provide for its future application to a large number of new and different uses with a minimum of engineering effort. This engineering in advance for any future relay of the step-by-step type has provided an interesting problem for the relay design engineers.

The step-by-step relay may be termed the "Erector Set" of the circuit designer's play room equipment. It includes fourteen different magnet assemblies and six different thicknesses and three different shapes of contact spring. The magnet assemblies each have the same size of core and spoolhead, but may be equipped with different lengths of copper slug or sleeve, and any of a number of windings can be applied to the magnets. The contact springs, shown in the accompanying illustration, may be assembled with a single standard thickness of insulator (except in a few special cases where a second thickness is required) to form various contact arrangements such as a make or break pair, or three springs in a break-make or make-before-break combination. Any number of these arrangements may be combined in a single pile of springs up to

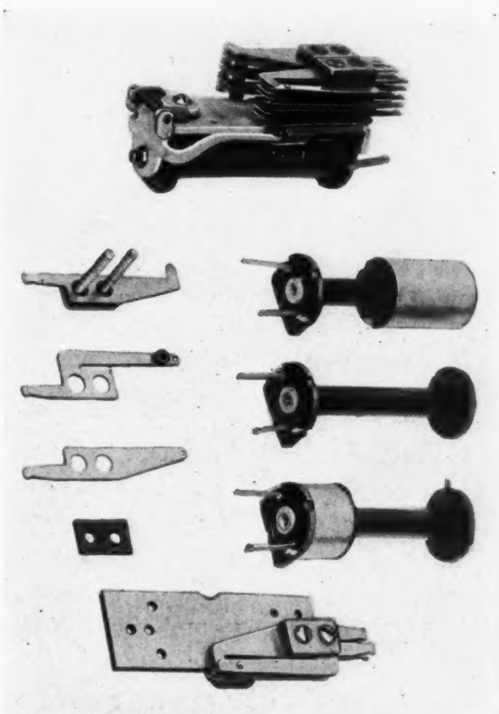


Fig. 1—The elements from which an indefinite number of step-by-step relays may be built up are here shown both individually and assembled into a typical relay

a possible maximum of fourteen springs, and two such contact assemblies can, if necessary, be mounted on and operated by one relay.

Omission of the usual insulating

bushing for the clamping screw of the assembly contributes to uniformity in assembly. The flat micarta insulators of the spring pileup have two embossings or upsets whose diameters fit the clamping holes in the contact

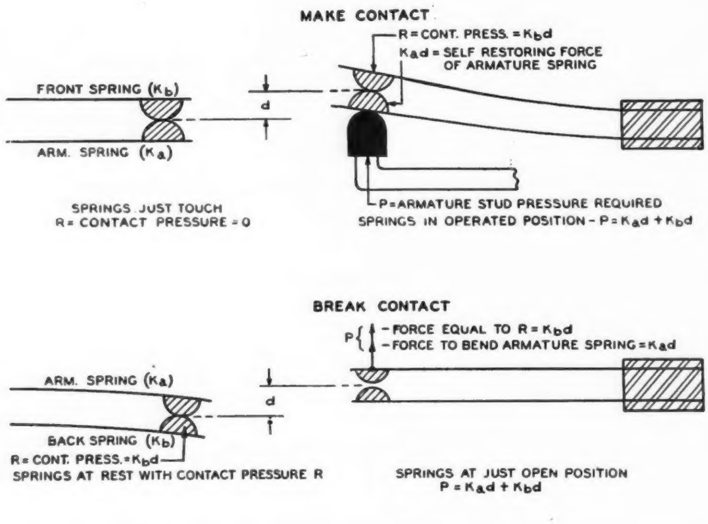


Fig. 2—Forces required to make normally open contacts, or to break normally closed ones are here shown diagrammatically. The additional force required to move the armature spring through a given gap separation is not indicated

springs. The screw holes in the insulator are drilled in the centers of these embossings so that contact between the screw and spring is prevented by the embossing which registers in the hole of the spring. With the use of an adjustable "non-freeze" stop, in the form of a brass screw in the armature, it is apparent that the assembly of this type of relay requires little effort beyond the proper selection of magnet and springs. To determine in advance, however, that any relay so assembled will function satisfactorily under specified circuit conditions, requires an engineering study of capability.

The engineering of a relay as an ordinary circuit element may be simply stated as follows. The necessary switching functions require a number of contact springs which must be moved to make or break certain contacts. The magnet is connected in a circuit whose electrical constants determine the amount of current which will flow in the winding. Size and heating limitations of the magnet spool determine the ampere turns which can be obtained with this current, and the magnetic pull resulting from these ampere turns must be sufficient to move the contact springs to make or break the required contact pressures. Although several additional and more complicated relations have to be considered in relay engineering, the foregoing indicates the necessity of providing two basic classes of information if the operation of various combinations of magnet and springs is to be predetermined. Capability data for this apparatus must, therefore, provide: (a), the pull to be obtained with any possible winding of any proposed magnet; and (b), the force required to move satisfactorily any proposed combination of contact springs.

Data applying to the magnetic pull of the different coils used are obtained by direct experiment, and presented for use in curve form. Laboratory observations are made of the pull resulting from various ampere turns for various gaps between the armature and core for each of the coils used,

and families of curves are plotted to show, within the possible working range, the minimum pull which may be expected with any value of applied ampere turns at any core gap. By reference to earlier work in capability engineering, giving the standard winding constants and methods of calculation, it is possible to discover the available ampere turns for any magnet in any proposed circuit, and thus to predetermine, by means of the curves, the pull in grams to be obtained from any proposed magnet.

Having thus examined the horse, the cart — or the load which the magnet must pull, next requires consideration. Although the total travel of the relay armature is less than 1/32″ (only .025″ perhaps, measured at the center of the core), several load changes occur during the travel as one spring after another is picked up. Since the pull of the magnet also changes during armature travel, rising at a steadily increasing rate from a very low value at the start to a relatively high value at the end, it is evident that, to forecast the successful operation of the relay not only the force required to make or break each contact of the assembly, but also the distribution of load in the armature stroke, must be predetermined. In terms of graphic analysis then, it is necessary to draw the load curve of any proposed contact assembly, and to compare it with the pull curve of the magnet with which it is to operate.

The fundamental requirements of contact pressure and contact separation serve as the basis of load curve determination. Since pressure at the contact is proportional to the spring deflection, a given contact pressure is, therefore, a measure of the deflection of the back spring of a break contact or of the front spring of a make contact. Added to this deflection or "follow," the contact separation defines the necessary motion of the springs which are directly carried by the armature. Determination of load value for the operation of any contact pair is therefore readily made as illustrated in Figure 2, when the load constants, or grams per .001″ deflection required, are known for the individual springs. These constants, Ka for the spring armature and Kb for the back spring, have been measured in the laboratory and tabulated for each shape and thickness of spring used, and these data alone would suffice for load curve prediction in the simple case illustrated in which the armature stud is applied in line with the contact.

In the actual contact assembly of this relay, however, the armature

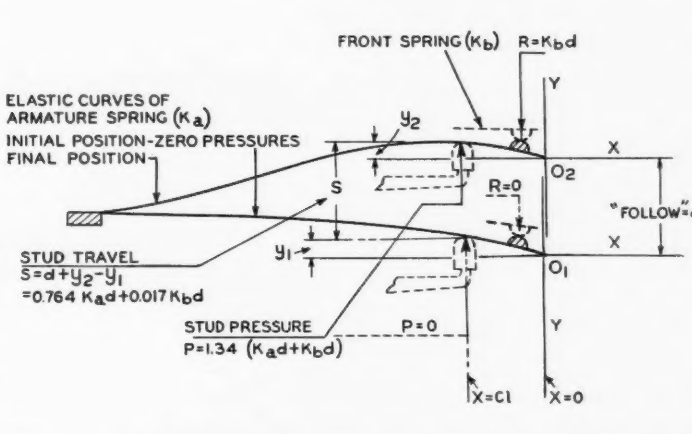


Fig. 3—Applying the operating force at a point between the contact and the fixed mounting, changes both the force that must be applied and the distance that the stud must travel

stud is applied to the springs as shown in Figure 3, and not in line with the contact. This introduces obvious difficulties in applying the simple reasoning of Figure 2. The motion at the stud may be materially different from the motion of the contact, due to the bending of the light armature spring about the stud. Also the force required at the stud is, of course, greater than that required at the contact for any given contact motion. It is convenient to use the elastic theory presented in standard textbooks which is commonly applied to the design of steel members in structural engineering. Solutions under this theory give workable values of force and travel required at the stud to produce any given contact pressure in terms of the build-up constants Ka and Kb of any individual contact springs. Although the relations in this case are more complex, it is possible to obtain from the elastic curve solutions a value of load constant, or grams per mil of travel or deflection at the stud, required for the operation of any contact group; and also the travel at the stud per gram of contact pressure at the contact.

To determine the distribution of load for the several contacts of the assembly throughout the armature stroke, and thus to predetermine a complete load curve, reference is made to the adjustment requirements for the relay which is schematically illustrated in the upper part of Figure 4. In the schematic, the core gap at the make or break of each contact pair is indicated by values in inches written between the springs. By this, the beginning or end of the "in-contact" travel of each set of springs is known. Hence it can be determined which pairs are moving "in-contact" and which armature springs are moving alone, at each point in the armature travel. It is then a simple matter to total the load resulting at any point in the armature travel and thus predict the complete load curve. From this the necessary ampere turns for operation or non-operation of the relay are determined by

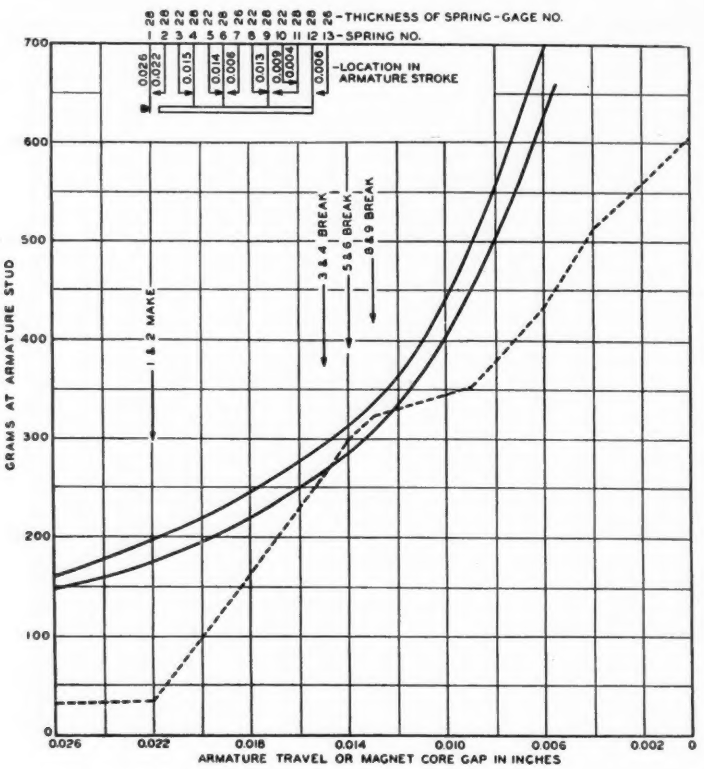


Fig. 4—By superimposing pull curves for different ampere-turns (solid lines) on the load curves (dotted) the proper winding to operate is determined

routine calculation. Previously it was necessary in each case to make an experimental determination of the load and ampere turns on an especially assembled and adjusted model.

As an illustration of the load curve and magnet pull curve comparison above described, the curves in Figure 4 have been prepared by G. B. Baker. These show a comparison of computed load on the large spring assembly schematically shown above the curves In actual application of course, the complete plotting of these curves is unnecessary. In actual application the ampere-turn determinations for operation are made by comparison of the progressive computed values of the load at each make or break point with the predetermined pull values of the coil at the corresponding core gaps.

The load and travel constants above referred to are obtained by formulae containing the stiffness constant of the individual springs which were computed from the results of laboratory load-deflection tests. This method, therefore, provides a ready means for determining the effect of any spring thickness or stiffness since the load curve can be recomputed with any values assigned, and limiting conditions can thus be introduced far more readily than could be done experimentally.

Sufficiently complete and general characteristics of the elements of the design have been obtained and tabulated to enable one to predict the operation of any anticipated arrangement of standard parts. These data have been arranged, and a method of use devised which involves a minimum of engineering effort; in recurrent application of these results to the solution of relay problems. This provides not only a systematic method of engineering relays to meet new circuit conditions but also a convenient means of checking the adequacy of relays employed in existing circuits.

The Policy of the Bell System

A reprint of part of an address delivered by Walter S. Gifford in Dallas before the National Association of Railroad and Utilities Commissioners*

There are today** over 420,000 stockholders of the American Telephone and Telegraph Company and no one of them owns as much as one per cent of the capital stock. The business of this Company and its Associated Bell Telephone Companies, whose common stock is largely owned by this Company, is to furnish telephone service to the nation. This business from its very nature is carried on without competition in the usual sense.

These facts have a most important bearing on the policy that must be followed by the management if it lives up to its responsibilities. The fact that the ownership is so widespread and diffused imposes an unusual obligation on the management to see to it that the savings of these hundreds of thousands of people are secure and remain so. The fact that the responsibility for such a large part of the entire telephone service of the country rests solely upon this Company and its Associated Companies also imposes on the management an unusual obligation to the public to see to it that the service shall at all times be adequate, dependable and satisfactory to the user. Obviously, the only sound policy that will meet these obligations is to continue to furnish the best possible telephone service at the lowest cost consistent with financial safety. This policy is bound to succeed in the long run and there is no justification for acting otherwise than for the long run.

It follows that there is not only no incentive but it would be contrary to sound policy for the management to earn speculative or large profits for distribution as "melons" or extra dividends. On the other hand, payments to stockholders limited to reasonable regular dividends with their right, as the business requires new money from time to time, to make further investments on favorable terms, are to the interest both of the telephone users and of the stockholders.

Earnings must be sufficient to assure the best possible telephone service at all times and to assure the continued financial integrity of the business. Earnings that are less than adequate must result in telephone service that is something less than the best possible. Earnings in excess of these requirements must either be spent for the enlargement and improvement of the service furnished or the rates charged for the service must be reduced. This is fundamental in the policy of the management.

The margin of safety in earnings is only a small percentage of the rate charged for service, but that we may carry out our ideals and aims it is essential that this margin be kept adequate. Cutting it too close can only result in the long run in deterioration of service while the temporary financial benefit to the telephone user would be practically negligible.

Our policy and purpose are the same as yours—the most telephone service and the best, at the least cost to the public. Without overlooking the fact that we lack the big money incentive for maximum profits and the drive for improvement that results from active and strong competition, we believe the telephone company is organized to make continuous and effective progress. . . . We shall continue to go forward, providing a telephone service for the nation more and more free from imperfections, errors or delays, and always at a cost as low as is consistent with financial safety.

** Printed in full in* BELL LABORATORIES RECORD, *December, 1927, page 101.*

*** October, 1927. At the present time the number is about 450,000.*

Vice-President Page Addresses the Laboratories

ARTHUR W. PAGE, Vice-President of the American Telephone and Telegraph Company in charge of public relations, talked on June 13 in our auditorium before the men and women supervising the work of the Laboratories. Introduced by Vice-President Charlesworth, Mr. Page extended President Gifford's outline of Bell System policy, delivered here two months ago, by discussing the problems attending the interpretation of that policy to the public which the System serves.

First pointing out the System's place in economic society, Mr. Page described the texture of services of which our civilization is composed, distinguishing between those performed by the entire public through its government, and by groups of the public. The interests of the public as a whole in most of the latter services are protected by competition among the several groups performing them, but in some cases the performance of a service is entrusted to one group and is guided in the public interest by regulation. Telephone service is so entrusted; and the Bell System, because of the large number of telephones and long lines which it operates, accepts this trust as a national responsibility.

With President Gifford's statement of Bell System policy in relation to this trust — to provide the most telephone service and the best at the least cost to the public — probably none would cavil; nor would any disagree that its familiarity with telephony should enable the System to find constantly improved ways of fulfilling that policy. But there is an embracing and historically natural suspicion toward the fidelity of all monopolies, a part of which, because of its national and thus monopolistic character, is directed toward the Bell System. Hence there is occasional disposition to question that the System actually means what it says in its statements of policy. As Mr. Page pointed out, the System's nature and deeds offer direct answers to such natural distrusts.

There is first a presumption that it is to the System's financial advantage not to follow its expressed policy — that it wishes to make more money than strict adherence to that policy would permit. The System's rejoinders to this suspicion are its promise and history of paying its owners only a reasonable and regular dividend, adequate to attract the necessary capital; of providing the stockholders with opportunities for further investment in the business from time to time; and of turning the surplus back into the service. In thus making the public the residuary legatee of its efforts, the System has been even more generous to it than law or regulation has so far seen fit to ask.

The System's financial behavior is to the public advantage not only directly in this way, but also indirectly,

by the elimination of capital waste. Organized in an era of exploitation which was characterized by the gain and loss of great individual fortunes, the System has uniquely made no great fortunes and lost money for no one. Its growth has been reasonable and steady, again as a result of conscious policy. Its composite owner, the 450,000 stockholders, unlimited in resource, do not die or retire at any one time, nor press a personal whim interfering with far-reaching programs which look to the continuous reduction of rates.

A notion also obtains that monopoly breeds slothfulness, inefficiency and arrogance. The public demands, for a rebuttal of these accusations, evidence of energetic efforts to bring to everyone the benefits whose provision has been entrusted to the monopoly, and to refine and improve the service. The System's activity in the former respect is embodied in its nation-wide sales program, reaching every element of the public with information regarding those services offered by the System which best suit particular needs. Insurance of progress and efficiency has been provided by setting up organizations exclusively devoted to the improvement of the System's procedures. It is in this capacity that the Laboratories plays its important part.

In the achievement of these ideals of operation in the public interest, monopolies can more swiftly and adequately progress without, than with, the restraints of external control, so long as the monopolies hold these ideals in good faith. Mr. Hoover, when Secretary of Commerce, enunciated this, and epitomized the attendant problems in the words, "The thing we all need searchingly to consider is the practical question of the method by which the business world can develop and enforce its own standards." The System's policy is its answer to the adjustment of big business to a democracy. Its deeds have borne out the genuineness of its words; and its efforts to follow a policy of public service have given rise to practices which constitute, in their application to the System, the "method" which Mr. Hoover sought.

News of the Month

F. B. JEWETT is named on a delegation of seventeen appointed by President Hoover to represent the United States at the World Engineering Congress meeting at Tokio on October 29. The congress will be held under the auspices of the Engineering Society of Japan and will discuss and exchange views on the latest knowledge of the science and practice of engineering. Mr. Jewett is scheduled to read a paper at the meeting. He attended a dinner given at the Carlton Hotel in Washington by the American Committee of the Congress in honor of His Excellency, Katsuje Debuchi, Japanese Ambassador to the United States.

While at Washington Mr. Jewett attended the annual meeting of the National Academy of Sciences. On the following day he was a guest at the White House luncheon at which the John Fritz Medal for 1929 was presented to President Hoover.

At the meeting of the Chicago Industrial Club in the Blackstone Hotel, Chicago, Mr. Jewett delivered an address on *What Industrial Research Has Done for Electrical Communication.*

On the occasion of the unveiling of the airplane *Bremen* on the Grand Central concourse, he was a guest of honor at a luncheon given by the Museums of the Peaceful Arts at Hotel Commodore. The luncheon was also attended by G. W. Elmen and P. Norton.

On June 7, Mr. Jewett gave the commencement address at California Institute of Technology, Pasadena, his subject being *The Scientist and Engineer as Citizens.*

Mr. Jewett has been made chairman of a committee appointed by the National Research Council to cooperate with the trustees of the Chicago World's Fair, which is to be held in 1933. The committee consists of representatives of the many fields of science in this country and will act as an advisory body in conjunction with the exhibitions of the achievements in science and invention during the last one hundred years, which are to be the dominant note of the Fair.

* * * *

MEMBERS of the Laboratories attending the Engineering Congress at Shawnee-on-Delaware included H. P. Charlesworth, R. L. Jones, H. D. Arnold, A. F. Dixon, H. H. Lowry, W. H. Matthies and B. W. Kendall.

RESEARCH

HERBERT E. IVES spoke at the one hundredth anniversary banquet of the Zelosophic Society of the University of Pennsylvania, of which he was president as an undergraduate. His subject was *Communication,* 1829 *and* 1929.

HARVEY FLETCHER, president-elect of the American Federation of Organizations for the Hard of Hearing, spoke over the N. B. C. chain on Thursday evening, June 20, on "Deafness." At the tenth annual convention of the Federation at Wade Park Manor, Cleveland, on June 24-27,

Dr. Fletcher was installed as president of the body.

KARL K. DARROW has left for California where he is giving a series of lectures at the summer session of Leland Stanford University on *Modern Physics* and *Advanced Theoretical Physics*. He expects to be absent from the Laboratories until the middle of September. He attended the meetings of the American Physical Society at Berkeley from June 19 to 23.

ON JUNE 3, C. J. Davisson spoke before a group of engineers of the American Telephone and Telegraph Company. His subject was *Wave Properties of Electrons*.

A. R. KEMP sailed on the "Aquitania" and J. J. Gilbert, V. E. Legg and J. F. Wentz sailed on the "Columbus" for Nordenham, Germany, where they will spend some time at the Norddeutsche Seekabelwerke, a subsidiary of Felten and Guilleaume of Cologne, in connection with the manufacturing development of submarine telephone cable.

C. H. G. GRAY sailed on the "Olympic" for London, Paris and Berlin, where he will discuss questions concerning the operation, application, and adjustment of the European Master Telephone Reference System.

D. G. BLATTNER left for Atlantic City on May 28 to attend the dedication of the recently erected Municipal Auditorium. The new auditorium contains one of the largest public-address and sound-picture equipment systems ever assembled.

DURING THE last week in May Mr. Blattner and H. F. Hopkins left for Orlando, Florida, to undertake tests with stethoscope transmitters in detecting the presence of Mediterranean Fruit Fly larvae in fruits. The tests were made in conjunction with Federal and State entomologists waging a campaign against the fruit fly larvae which are causing much damage to citrus fruits.

H. A. FREDERICK, with G. D. EDWARDS and A. F. GILSON of the Inspection Engineering Equipment, attended a conference of the Instrument Repair Committee at Hawthorne.

MEMBERS of the Research Department who attended the meeting of the American Chemical Society at Columbus included W. S. Bishop, C. L. Erickson, R. L. Taylor, R. M. Burns, H. H. Lowry, L. A. Wooten and L. H. Campbell.

R. M. BURNS, B. L. CLARKE, W. E. CAMPBELL, and H. E. HARING attended the meeting of the American Electrochemical Society at Toronto. A paper, *Electrical Resistance Method of Measuring Corrosion by Acid Vapors*, was presented by Messrs. Burns and Campbell.

L. H. CAMPBELL visited the Dupont Paint Laboratories in Philadelphia on May 9 and 10.

J. H. INGMANSON was in Texas in connection with the installation of tape armored cable.

P. A. LASSELLE was at the plant of the General Electric Company at Schenectady for the purpose of inspecting enamelled wire.

E. E. SCHUMACHER, J. H. WHITE and G. M. BOUTON made an inspection trip through the Bethlehem Steel Company.

J. A. BECKER presented a paper entitled *The Life History of Adsorbed Atoms and Ions* before the meeting of the American Electrochemical Society at Toronto.

A PAPER by H. A. Pidgeon and J. O. McNally, entitled *A Study of the Output Power Obtained from Vacuum Tubes of Different Types* was pre-

sented at the June meeting of the Institute of Radio Engineers.

Inspection Engineering

G. D. Edwards made visits to the Field Engineering Headquarters in Cleveland, Chicago and St. Louis during the latter part of May. Accompanied by G. Garbacz, Cleveland Field Engineer, Mr. Edwards also visited the Cincinnati and Suburban Telephone Company in Cincinnati in connection with inspection engineering work.

Mr. Edwards attended some of the meetings of the conference of operating company chief engineers held at Shawnee-on-Delaware.

During the first week in June, A. F. Gilson and S. H. Anderson were at the Elgin central office in Toronto in company with representatives from the General Electric Company to investigate and correct commutation difficulties experienced on an M-type generator.

W. E. Whitworth, Omaha Field Engineer, visited Fargo, Denver and Minneapolis in connection with field engineering activities.

R. M. Moody, H. C. Cunningham and C. J. Hendrickson were in Hawthorne, and Mr. Cunningham was also in Kearny to attend surveys of inspection and quality control methods for plugs, jacks, keys and relays.

R. C. Koernig visited Hawthorne to confer with the Manufacturing Department of the Western Electric Company regarding remedial measures in connection with engineering complaints.

Outside Plant Development

C. S. Gordon visited the Reliable Manufacturing Company of New Haven in connection with the production of strand dynamometers. While at New Haven Mr. Gordon also visited the Whitney-Blake Company in regard to drop-wire production.

C. H. Klein and B. A. Merrick were at New Haven during the latter part of May to witness field trials on span clamps.

S. C. Miller and A. W. Dring made a trip to Hawthorne to discuss matters concerned with the redesign of No. 14 Type Cable Terminals. Mr. Dring conferred with officials of the Bell Telephone Company of Pennsylvania in connection with the same work.

D. A. Quarles, J. B. Dixon, and E. M. Honan visited the Roebling Steel Wire Company of Roebling, New Jersey, on a trip sponsored by the New York Electrical Society. The visit was made for the purpose of inspecting the manufacture of suspension wire to be used on the new Hudson River bridge.

C. R. Moore made a trip to Washington to study methods of detecting leaks in cable held under gas pressure, in connection with work of the Long Lines Department. Mr. Moore was also at Philadelphia to study warning devices applicable to cable-leak detection. On May 20 he was at Mount Vernon, Tarrytown and Peekskill, carrying out investigations of methods of loading and blocking cable reels on freight cars.

D. A. Quarles, G. A. Anderegg, and C. D. Hocker made a trip to Texas during May, visiting chiefly the cities of Dallas and Fort Worth, to examine the condition of tape-armored cable buried in that region. Mr. Hocker extended his trip to San Antonio and Galveston to investigate motor-vehicle and metal finishes. He also stopped off at New Orleans to

supervise the burying, for experimental purposes, of cable-lead and iron samples covered with various protective coatings. On the return trip Mr. Anderegg spent a few days at Hawthorne to discuss general cable development matters.

SYSTEMS DEVELOPMENT

L. M. ALLEN spent several weeks in Denver in connection with circuit problems and the cutover of step-by-step equipment there. The cutover to the dial system was one of the largest in the country, involving the entire downtown section of Denver, which included about 40,000 offices. H. H. Lowry was in Denver as a guest of the Mountain States Telephone and Telegraph Company at the time the cutover was made.

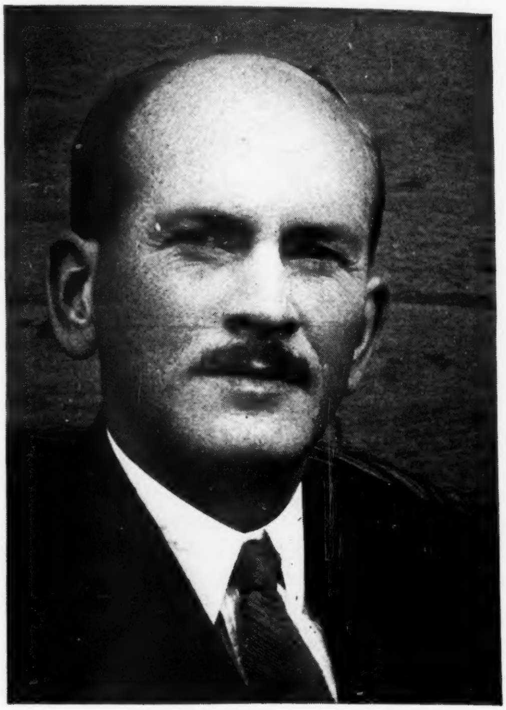
F. S. ENTZ, A. E. BACHELET and B. A. FAIRWEATHER visited Allentown in connection with tests of program transmission over cable circuits. Mr. Fairweather also visited Morristown, Reading and Harrisburg in carrying on these studies.

D. M. TERRY, W. F. KANNENBERG and C. M. HEMMER were in Richmond during the past month to observe trials on 2-A automatic pilot-channel equipment.

D. E. TRUCKSESS was in East Pittsburg to discuss power problems with engineers of the Westinghouse Electric and Manufacturing Company, and in Fort Wayne to discuss similar problems with General Electric engineers.

J. A. KRECEK was in Chicago in connection with the installation of four-wire echo suppressors.

EVERETT HARRISON SMITH died on June 11 after an illness of three months. Born in 1887 in Leicester, Massachusetts, Mr. Smith attended Worcester Polytechnic Institute, and joined the Western Electric Company at Hawthorne in 1910. He was transferred to West Street for systems



E. H. Smith

engineering in 1919. Here Mr. Smith participated in the design of machine switching systems, and at the time of his death was in charge of the development of step-by-step dial equipment. The Laboratories deeply regrets the passing of so efficient a co-worker and so kindly a friend.

M. A. FROBERG visited Chicago and discussed various equipment problems with members of the staff at Hawthorne.

R. P. JUTSON visited Greensboro and Durham, North Carolina, where trials are being made on unit power supply equipment for repeater stations.

H. N. BOWMAN was in Hawthorne in connection with the manufacturing of a new design of testing equipment

which is replacing the present type of portable test boxes and test wagons.

H. E. MARTING was in Cincinnati to discuss building and floor-plan layouts with engineers of the Cincinnati and Suburban Telephone Company.

J. R. STONE and G. A. BENSON were in Des Moines in connection with the installation of centrifugal exhauster equipment for use with distributing systems for toll tickets.

H. M. SPICER was in Philadelphia to discuss the manufacture of power switches with General Electric Company engineers.

E. J. DONOHUE went to Syracuse to observe trials on out-trunk preselector equipment.

J. H. SOLE visited the General Electric Company plant at Schenectady to discuss alternator designs.

C. E. BOMAN and F. H. GRAHAM were in Hartford in connection with studies of step-by-step equipment.

C. E. BOMAN has been elected to membership in the Edward J. Hall Chapter of the Telephone Pioneers of America.

FERDINAND VOELKER, JR., of Toll Development, died May 12, 1929. Mr. Voelker had been with the Western Electric Company and the Laboratories since February, 1920, coming to us directly after his graduation from high school. He was an honor student in the Student Assistants' course and by virtue of his work in Equipment Drafting division was promoted into Equipment Engineering. Although only twenty-six years of age at the time of his death, Mr. Voelker had already established a high reputation in the performance of his duties with the Laboratories.

APPARATUS DEVELOPMENT

F. F. LUCAS visited the Watertown, Massachusetts, Arsenal to discuss metallurgical problems in connection with the manufacture of army ordinance with the Arsenal staff. On the twenty-first he was the guest of honor at a dinner at Henry Ford's Wayside Tavern, Sudbury, Massachusetts. On the twenty-second, Dr. Sauveur of Harvard and Mr. Lucas were the guests of honor at a dinner attended by members of the Harvard and M. I. T. faculties at the Harvard School of Business Administration.

C. E. NELSON spent the month of May and part of June in Harrisburg, Pennsylvania, in making noise measurements in the step-by-step office there. E. Montchyk also visited Harrisburg in this connection and D. W. Mathison conducted various experiments in reduction of noise at the same central office.

L. E. DICKINSON visited Hartford, during the month of May to measure contact resistances in the step-by-step office.

H. B. ARNOLD attended the National Electric Light Association convention at Atlantic City to explain the various technical aspects of power-line carrier equipment displayed in the Graybar exhibit at the convention.

J. E. CROWLEY spent several weeks at Atlantic City in connection with the installation of the public-address system in the convention hall.

O. L. WALTER visited Hawthorne to discuss changes in the manufacture of 202-B Reproducer Sets. Mr. Walter also spent several days at White Sulphur Springs handling the portable reproducer during the convention of general managers of Associated Companies.

R. V. TERRY spent several days in Rochester visiting the Bausch & Lomb Optical Company and the Eastman

Kodak Company in connection with reproducing lenses for sound pictures.

J. N. REYNOLDS and H. F. DOBBIN visited Hawthorne recently in connection with development work on dial apparatus.

W. T. PRITCHARD attended a conference at Harrisburg, Pennsylvania, with representatives of the American Telephone and Telegraph Company and the Bell Telephone Company of Pennsylvania on maintenance apparatus for the step-by-step dial system.

F. A. VOOS visited Hartford on May 31 to inspect the lubrication of master-switch governors.

G. W. FOLKNER and C. W. McWILLIAMS were at Hawthorne in connection with new developments on multiple brushes and banks.

H. M. KNAPP and E. P. WILLIAMS were in Hawthorne during the week of June 3, to observe manufacturing methods.

B. F. RUNYON spent several weeks at Kingston, New York, on special studies of contacts in pilot-wire regulators for toll lines.

H. N. WAGAR was at Hawthorne for a month of engineering training.

J. E. SHAFER visited the radio station at Lawrenceville, New Jersey, in connection with development of overload relays.

J. R. FRY was at Hawthorne recently for a conference on magnetic materials for electro-magnetic apparatus.

W. L. BLACK and H. V. AKERBERG are supervising the installation of the speech input equipment for the new studios of the Columbia Broadcasting System in New York City.

A. B. BAILEY was in Gloucester to supervise the installation of the one-kilowatt broadcasting equipment for the Matheson Radio Company. He inspected similar equipment for the Outlet Company of Providence.

J. C. HERBER supervised the conversion to crystal control of the one-kilowatt broadcasting equipment of the Petroleum Telephone Company, Oil City, Pennsylvania. F. A. Hinners was in Akron performing a like service for the Allen Theatre.

O. W. TOWNER inspected the one-kilowatt broadcasting equipment of the Concordia Seminary, and the five-kilowatt broadcasting equipment of the Voice of St. Louis, both of St. Louis. During the past month he was at Raleigh to supervise the installation of the one-kilowatt broadcasting equipment of the Durham Life Insurance Company. Mr. Towner also supervised the installation and conversion to crystal control of the one-kilowatt broadcasting equipment of the Hotel Lassen, Wichita, Kansas.

PATENT

BETWEEN MAY 8 and JUNE 6, G. M. Campbell, E. V. Griggs, J. A. Hall, G. C. Lord, T. P. Neville, O. E. Rasmussen visited Washington in connection with the prosecution of patents. P. C. Smith was at Rochester during the past month on a similar mission.

GENERAL STAFF

ON MAY 14, S. P. Grace addressed the Los Angeles section of the American Institute of Electrical Engineers and a week later spoke before the combined meeting of the San Francisco sections of the American Institute of Electrical Engineers and Institute of Radio Engineers. While on his Pacific Coast tour, Mr. Grace also spoke before the Oregon Technical Society at Portland; the Engineering Society at Seattle; and the local sec-

tion of the American Institute of Electrical Engineers at Spokane.

W. C. F. FARNELL spoke before the General Conference Board of the Engineering Association of the Southern New England Telephone Company at Norfolk.

L. S. O'ROARK was a speaker at the annual convention of the Telephone Association of Vermont at Burlington; his subject was *Electrical Eyes*.

CONRAD SCHAUL, who has been with the Western Electric Company and the Laboratories for the past thirty-six years, employed as an instrument maker in the Development Shop, has been retired at his own request on May 20, 1929, and is now residing at 1033 Madison Street, Brooklyn.

JOHN LAWLESS, formerly of the Plant Department, died May 28, 1929. Mr. Lawless, whose service with the Western Electric Company and the Laboratories dated from November 12, 1901, was retired on pension June 13, 1928.

* * * *

A SERIES of night flights, from Hadley Field to Washington and return, was made by the Laboratories' plane from May 22 to May 25. These flights marked the first attempts on a comprehensive basis to undertake night experiments on radio telephonic communication between the plane in flight and the ground.

About two hours were required to make the trip each way. The flights were started shortly after dusk, landings were made at Bolling Field, Washington, and the return trips were started about midnight. Experimental trials were made at four different frequencies between 1500 and 6000 kilocycles. During most of the journey two way communication was maintained between the plane and the laboratory at Whippany. On three of the four frequencies, good telephone signals were had at Whippany as the plane soared high above the city of Washington. A model of the recently developed 50-watt No. 8-A Radio Transmitter was used in the plane during all of these tests.

Quite satisfactory flying conditions were encountered with the exception of the third flight on Friday, May 24, when, owing to frequent thunder showers, the return trip was made without landing at Bolling Field. On the first and third flights the plane was piloted by Capt. A. R. Brooks and the radio equipment was in charge of F. S. Bernhard. The plane was piloted by Thomas Durfee on the second and fourth flights, with E. F. Brooke in charge of the radio equipment.

The experiments undertaken during the past month, round out the plane's first year of service. In this period more than 260 flights have been made representing a total mileage in excess of 25,000 miles.

* * * *

A DEMONSTRATION of radio telephone transmission by the Laboratories' plane was given before the Board of Directors of the American Telephone and Telegraph Company on June 12, previous to the Board's regular meeting. The plane circled over lower New York within sight of the A. T. & T. building at 195 Broadway, permitting Directors to observe the plane as they talked over the radio telephone with Capt. A. R. Brooks who was at the controls. W. C. Tinus and W. E. Reichle of the Radio Development group of the Laboratories were in charge of the radio telephone

transmission apparatus in the plane.

Connection was made through the ground station at Whippany, over one of the regular trunk lines from Whippany to Jersey Toll, thence to the executive switchboard at 195 Broadway. Transmission from the plane to the ground was carried on at a frequency of 1608 kilocycles. Members of the Board of Directors who took part in the demonstration were: James S. Alexander, George F. Baker, George F. Baker, Jr., Charles P. Cooper, George P. Gardner, Walter S. Gifford, Henry S. Howe, and Owen J. Roberts.

Contributors to this Issue

W. WILSON, after receiving the B.Sc. degree from the Victoria University of Manchester, England, in 1907, pursued graduate work for three years there and for two years at the Cavendish Laboratory of Cambridge University. From 1912 to 1914 he was Lecturer in Physics at Toronto University—meanwhile receiving the D.Sc. degree from Manchester—then joined the vacuum tube research group of these Laboratories. He has been active in transatlantic and ship-to-shore telephonic development, and is now Assistant Director of Research in charge of groups concerned with radio and with vacuum tubes.

L. A. ELMER received the B.S. degree from the University of Minnesota in 1921, and the M.S. degree in mechanical engineering from Massachusetts Institute of Technology the following year. Coming directly to these Laboratories, he spent two years in the machine switching testing laboratory, and then joined the group engaged in developing the mechanical equipment for wax recording. He has been especially concerned with the design of vibration-absorbing drives.

Carrier current development has been the chief activity of Christian F. Boeck since he entered the Laboratories in 1919. In particular he was active in the initial installation of the Type B system, and in the development of picture transmission. He has been connected with power-line carrier since its early days and had charge of laboratory work on the single side-band system which he describes in this issue of the RECORD. Subsequently he took part in the installation of this equipment. While continuing his interest in power-line carrier, Mr. Boeck and his group have recently been concerned with public-address engineering, and with the installation of sound-picture equipment on trucks.

Mr. Boeck is an alumnus of Carroll College, Wisconsin, and had three years of graduate engineering studies at Wisconsin and Columbia.

F. H. HIBBARD attended Huron College and Cornell University, receiving the M.E. degree in 1914. After two years with the Western Electric Company, and a short time with the Maxwell Engineering Company and with United Theatre Equipment as Sales Engineer, he joined these Laboratories. From the dial apparatus testing laboratory, of which he was in charge after 1921, he moved for a short time into cost-reduction

Christian F. Boeck

W. Wilson

L. A. Elmer

work, then into the group developing electromagnetic apparatus, to supervise the design of step-by-step relays. Mr. Hibbard is now a member of Electrical Research Products, Inc.

When in 1919 Herbert E. Ives entered the Laboratories, he had already accomplished much in the field of optics, notably in color photography, in photometry, and in the production of "artificial daylight." Bringing to his new work an extensive knowledge of the photo-electric cell, Dr. Ives was placed in general charge of developments leading up to the telephotograph system, put into commercial operation in 1925. He was in charge as well of the development of the television system initially demonstrated in 1927. He directs a group which investigates not only the general problems of picture transmission and television, but such specific details as the photo-electric cell and the glow-discharge lamp.

Sixty per cent of the world's telephones are in use in the United States, according to recently published world telephone statistics. These statistics, compiled up to January 1, 1928, *show that the total number of telephones in the world on that date amounted to* 30,990,304, *and the actual number possessed by this country was* 18,522,767. *Europe had* 8,623,407 *telephones, or about* 28 *per cent of the world's total, and the remaining* 12 *per cent were distributed widely throughout the rest of the world. The year of* 1927 *showed an increase of* 1,583,743 *in the total number of telephones in use, one-half of which representing those added in the United States.*

Notes of the Club

THIRTY brightly colored bathing caps flashed and dipped, porpoise-like, in cool green waters while watchful judges and envious spectators looked on from the vantage point of a nearby golf course. The occasion was a water sports competition for Club mermaids on the initial women's night at the In-

door Athletic Club, June 5. The scene resembled the Hollywood idea of a pool party on a Long Island estate, what with the golf green, gay colored chairs and bathing girls.

After warming-up exercises on the vibrators and handball courts, the girls were ready for the water races under the expert direction of Miss Wyckoff of the Kittredge School and Miss Spranger of the Carroll Club. Miss Spranger had the pleasure of seeing some brilliant performances by her erstwhile pupils in the swimming classes. The lone aerial event on the program was the balloon race. Only a few girls succeeded in pushing a toy balloon the length of the pool but, owing to the difficulty in keeping a straight course, all had admirable success in pushing each other the width of the pool. Less spectacular but more picturesque was the affair called the Statue of Liberty or candle race. Several maidens gracefully glided down the pool each bearing aloft a lighted candle. One elected the submarine style but was beaten out by the faster sub-chasers.

In the sixty-foot splash and dash finals, Patience Penney nosed out Marianne Grimm for first place. In the walking race, Mary Reddington walked away from Valerie Beers and the remaining entrants to win first place, Miss Beers finishing second. In the Dead Man's Float, Mabel Wood and Margaret Tully floated longer, farther and better than the others, taking first and second place.

A novelty was the Chip Picking contest in which Marie O'Neil showed an uncanny eye for poker chips by finding seventeen at the bottom of the pool. Miss Jackson was next with fourteen chips.

The candle race finished as follows: Louise Fitzgerald first, Virginia Rathgeber second. Patience Penney won first as the best balloon pusher and Florence McCann was next best.

Medals were awarded to the winners of first places and pins to those of second places.

The dive-and-sprint racers were not only fast, but impartial in their splashing. L. P. Bartheld, who acted as master of ceremonies, timekeeper and candle lighter, had a natty gray suit

put badly out of press by reckless splashers. Marie Boman and Leona Feil also had the misfortune to be splashed. In fact, a good splashing was enjoyed by all.

The swimmers and spectators were then treated to an exhibition of various styles of swimming and life-saving by the Misses Spranger and Wyckoff which was received with generous applause. The meet then broke up into free-for-all swimming and diving, golf, handball, the showers, and the free-for-all subway ride home.

E. C. Mueller sinks a long putt

FORE!

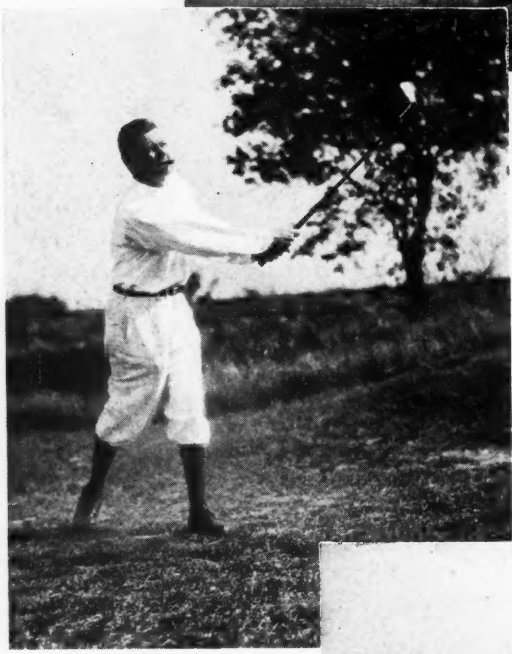
Traps to the right of them and bunkers to the left of them, into the wind drove the 81 — and so started the golf tournament at the Salisbury Country Club.

The day, Saturday, June 1, was perfect for golf and from the number of scores under 90 our Hagens, Farrells and Diegels forgot what might happen to their handicaps and shot some near-par golf. In Class "A," Kellogg turned in the lowest score for all B. L. C. tournaments, a gross 79, and won the low-gross prize for qualifying round. Clark, Hillier, Cesareo, Achenbach and Wood were right behind him with scores in the eighties. Class "B" had nine men breaking 100 and the honors in this class were shared by E. Peterson and T. P. Ingram. Korn led Class "C" with a gross 101, net 67, followed closely by Greenidge who had a gross 103 and a net 68. Achenbach and Ingram were tied for the low net prize in the qualifying round, but Ingram's net 63 in the finals was low enough to defeat Achenbach.

Fairlamb grazes the edge of the cup

The finals were held Saturday, June 8, and reminded one of those cold windy days we hear so much about on the golf courses of Scotland. The first three foursomes teed off in the rain but the gods were good — the rain stopped and the wind died out, leaving our men a perfect golf day and incidentally lots of work for the handicap committee.

The prizes were awarded on the basis of total gross and net scores for 36 holes. Low-gross prizes were wrist watches and were won by Kel-



Above, Bart explodes one out of the sand; left, "Jonny spielt auf"; below, Leon Hoyt gives Andy Lawrence a lesson on how to chip up

Above, Chairman Kennelty raises a smoke screen; right, believe it or not, Kellogg turned in a gross 79; below, Achenbach drives out a long one

logg, Class "A," with a total 165 for 36 holes; in Class "B" by Hoyt with a 185; and by Korn in Class "C" with 201. Trophies were awarded for the low net scores in each class and were won by Achenbach, Ingram and Crawford. Wallets for the second low net scores were won by Downing, Lacerte and Bittner in their respective classes. Golf balls for third low net were won by Clarkson in Class "B" and Greenidge in Class "C."

The fall tournament will be held at the Salisbury Country Club on Saturdays, September 21 and 28.

Beach Combing at Brighton

Retaining its ancient glamour of the horse and carriage era as a select bathing resort, Brighton Beach in modern dress continues to attract the seekers after salt air and sea bathing. Rapid transit facilities and the longer day make it possible to dip in the brine after a hot day's work and loaf back to town in a 40-an-hour bus. And then the Club arrangement for special half-price tickets goes for Saturdays and Sundays also, enabling bathers to avoid the usual long lines. The Club feels it is fortunate in having secured these special privileges for its members, and if tickets sold is a criterion the Club members likewise endorse the idea. Tickets on week-days are only fifty cents and on Sundays and holidays one dollar. Club membership cards must be shown with tickets which are available from the Club secretary, Room 164.

Carroll Club Swimming Classes

Swimming classes are again being held during the summer season at the Carroll Club. This gives an opportunity to those who have benefited so much in the past by the swimming classes to continue their progress under the Misses Spranger and Wyckoff. New swimmers who are interested are also welcome and should get in touch with Katherine Tully.